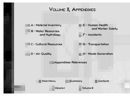

Click here to return to the Volume II Menu

E

Human Health and Worker Safety

APPENDIX E – HUMAN HEALTH AND WORKER SAFETY

E.1 INTRODUCTION

E.1.1 Purpose

This appendix describes the methods used to assess potential human health impacts associated with chemical exposures, radiation exposures, and worker safety issues due to the Sandia National Laboratories/New Mexico (SNL/NM) operations described under each of the alternatives: No Action, Expanded Operations, and Reduced Operations. Human health impacts were addressed using the sliding scale approach described in the U.S. Department of Energy's (DOE's) *Recommendations for the Preparation of Environmental Assessments and Environmental Impacts* (DOE 1993b). Human health risks were provided to represent the potential for adverse health effects and were compared among the alternatives.

All significant exposure pathways were evaluated. The analysis focused on evaluating impacts at specific receptor locations from air emissions associated with routine operations. The analysis presented potential health effects applicable to workers, public receptors in the SNL/NM vicinity, and the population within 50 mi of SNL/NM. Potentially sensitive individuals were also considered by assessing exposures and health risks at specific receptor locations in the SNL/NM vicinity.

E.1.2 Objective

The objective of this risk analysis was to evaluate the potential risks associated with human exposure to environmental media (that is, groundwater, air, or other such environmental media) that may be affected by radiological materials and other chemical constituents used in SNL/NM facility operations. Radionuclide and chemical constituents may be transferred to environmental media by way of routine air emissions from stacks, sporadic air emissions from open burning, transportation of radiological materials, or accidental release. When there is the potential for human contact with the affected medium, it is referred to as a complete exposure pathway. The Site-Wide Environmental Impact Statement (SWEIS) identified the air pathway as the primary complete exposure pathway that had the potential to transport materials directly from SNL/NM to locations where human receptors may be exposed directly through inhalation. The secondary exposure pathways identified included ingestion of crops contaminated by deposition of radiological airborne materials and livestock products from animals that ingested contaminated crops. Chemical and radiological contamination existing in the environment (such as soil and groundwater) at SNL/NM were also evaluated as potential transport pathways related to SNL/NM operations.

Estimated indicators of potential risk, or detriment, to human health were summarized both quantitatively and qualitatively in the following terms: fatal cancer risks, nonfatal cancers, latent cancer fatalities (LCFs), hazard indexes (HIs), individual excess lifetime cancer risks (ELCRs), and genetic disorders. The quantitative values were calculated based on actual and/or modeled data for contaminants transported in these media and the subsequent possible levels of human exposure to them.

The risk scenarios that were analyzed included

- inhalation of chemically contaminated air at specific receptor locations, including onsite, offsite, and specific receptor locations under visitor, residential, and hypothetical worst-case exposure scenarios;
- inhalation of radiologically contaminated air at specific receptor locations, including onsite, offsite, and specific receptor locations, and at the maximally exposed individual (MEI) (normal operations) receptor location;
- ingestion of radiologically contaminated agricultural produce and animal products due to radiological air releases within the 50-mi region of influence (ROI) and at the MEI (normal operations);
- external radiation exposure from radionuclide emissions and subsequent material deposition onto the ground, including plume and groundshine; and
- external radiation exposure from the transportation of radioactive materials within the 50-mi ROI.

E.2 BACKGROUND

E.2.1 Environmental Setting

Due to its location, any environmental releases from SNL/NM operations would have the potential to affect members of the public. Specifically, impacts to air quality, water quality, and other environmental resources necessary for maintaining public health are at issue for human health and worker safety.

Affected areas or receptors pertinent to the human health and worker safety assessment included all individuals or populations potentially exposed to routine radionuclide and chemical releases from SNL/NM, as well as workers who are potentially affected by their routine work duties.

E.2.2 Environmental Impacts Sources

SNL/NM encompasses hundreds of different facilities and conducts a multitude of tasks within these facilities. For purposes of the SWEIS, specific facilities related to the main activities at SNL/NM were examined in detail to determine impacts to the environment due to alternative operations of these facilities. The assumptions provided for selected facilities were used to formulate data representative of impacts to human health under each of the three alternatives.

The human health impacts assessment focused on the selected facilities that were determined to contribute the majority of the releases of chemicals and radiological contaminants to the environment. The largest contributors of chemical air emissions were located in Technical Area (TA)-I. The largest contributors of radiological air emissions were in TAs-IV and -V. The outdoor test facilities within Kirtland Air Force Base (KAFB) on land surrounding SNL/NM were responsible for the sporadic air emissions caused by open burning and explosives testing. Chemical emission sources evaluated included Buildings 858, Microsystems and Engineering Sciences Applications (MESA) Complex, 878, 905, 870, 897, and 893 in TA-I and 6580 in TA-V. Radiological emission facility sources evaluated included Buildings 6588, 6920, 6590, 6580, 905, 970, and 870 in TAs-I, -II, -III, -IV, and -V.

E.3 DATA EVALUATION

E.3.1 Data Sources

Data outputs from the following resource area impact analyses were used in preparing the human health and worker safety analysis:

- Radiological Air Quality
- Nonradiological Air Quality
- Hydrology, Geology, and Soils
- Transportation and Waste Generation

Table E.3–1 identifies the specific data and the sources used in conducting the human health and worker safety analysis under each of the alternatives.

E.3.2 Screening Analysis To Determine Chemicals of Concern

The SNL/NM Chemical Information System (CIS) database, CheMaster database, and the Hazardous Chemical Purchases Inventory (HCPI) database are the sources of information used to identify chemicals of concern (COCs) for impacts to human health by way of the air release pathway. These databases contain thousands of entries identifying chemical products used at SNL/NM. Solids, liquids, gases, and common cleaners and paints are included in these databases. All possible chemical sources at SNL/NM are evaluated for the potential to routinely release chemical air emissions to the environment. Only chemicals in large enough use at SNL/NM and with certain specific chemical properties are considered to have the potential to be emitted to the environment as routine building air emissions (see Appendix D, Section D.1.3, for details on the chemical screening process).

In summary, the chemical screening process involves a progressive series of steps to select chemical pollutants of concern. Methods involved conservative, as well as more rigorous, process engineering estimates of air emissions. This approach, consistent with U.S. Environmental Protection Agency (EPA) guidance, focuses detailed analyses only on those chemicals that are routinely emitted (occurring daily from ongoing normal operations at SNL/NM) and have a reasonable chance of being a health concern.

Emissions of COCs remaining after the screening process described in Appendix D were referred for an assessment of potential effects on human health. COC lists for each alternative containing both carcinogens and noncarcinogens from facility operations are in Tables E.3–2 through E.3–4. Table E.3–3 includes information regarding the MESA Complex configuration, if implemented. Chemicals with human health dose-response information are part of the quantitative health risk assessment. A reference dose (RfD) associates exposure to a chemical to a human health effect. Several EPA database reference sources containing dose-response information for chemical constituents were searched. If no inhalation dose-response information was identified for a chemical, that chemical was qualitatively evaluated. None were identified that would affect the final health risk values. Because of specific chemical properties (not an inhalation health hazard, not persistent in the environment, not in large quantity), it was reasonable to screen these chemicals from the assessment (Appendix D, Section D.1). Specifically, these chemicals did not pose a chronic exposure health threat. This overall method used

Table E.3–1. Data Used in Human Health Consequence Analyses

PARAMETER	SOURCE
WORKER SAFETY (Appendix E)	
Total number of SNL/NM FTEs predicted under each alternative	*SNL/NM Facility Safety Information Document* *Environmental Information Document*
RADIOLOGICAL AIR QUALITY (Appendix D)	
Radiological doses (mrem) at each selected receptor location (offsite and onsite) and the MEI under each alternative	Output from radiological air quality analysis (*CAP88-PC*)
Collective population dose (person-rem) for 50-mi for each alternative	Output from radiological air quality analysis (*CAP88-PC*)
Dose/risk conversion factors (LCF/10^6 person-rem)	Literature (NCRP)
NONRADIOLOGICAL AIR QUALITY (Appendix D)	
Annual average concentrations (mg/m^3) of COCs at selected receptor locations (offsite and onsite) and the maximum COC concentrations under each alternative Annual average concentrations (mg/m^3) of carcinogenic air pollutants at the radiological MEI receptor location under each alternative	Output from air quality analysis (*ISCST3*)
Inhalation exposure parameters (duration [yr], frequency [hr/day], breathing rate [m^3/hr], risk factors [mg/kg/day]) for each receptor	Literature (EPA *Exposure Factors Handbook*)
Air quality impacts from open burning activities at SNL/NM under each alternative	Output from air quality analysis (*OBODM*)
HYDROLOGY/GEOLOGY/SOILS (Appendix B and Chapter 5)	
Highest concentration (mg/L) of chemicals or (pCi/L) of radiological contaminants at any affected drinking water supply wells to occur within 10 years The "peak" contaminant concentrations (mg/L) and timeframe (yr) for it to occur at these wells	Output from hydrology/geology/soils analysis (No impacts reported)
Summary of water quality (concentrations of constituents above water quality standards) in any affected spring, stream, or arroyo under each alternative	Output from hydrology/geology/soils analysis (No impacts reported)
Summary of soil contaminant levels (mg/kg) where concentrations show impacts under each alternative	Output from hydrology/geology/soils analysis (No impacts reported)
Ingestion exposure parameters (duration [yr], frequency [days/yr], intake fraction [%],intake factors [mg/kg/day], ingestion rates [L/day]) for each receptor	Literature (EPA *Exposure Factors Handbook*)
Dose/risk conversion factors (LCF/10^6 person-rem)	Literature (NCRP)

Table E.3–1. Data Used in Human Health Consequence Analyses (concluded)

PARAMETER	SOURCE
TRANSPORTATION (Appendix G)	
Population collective dose (mrem) during routine radiological materials transportation activities within the 50-mile ROI under each alternative	Output from transportation analysis (*RADTRAN4*)
MATERIAL INVENTORY (Appendix A)	
Quantities of chemicals purchased in key facilities projected for each alternative	SNL/NM selected facility source documents

Sources: BEIR V 1990; DOE 1997e; EPA 1989, 1995a, 1996a, 1996b; ICRP 1991; SNL/NM 1996n, 1997a, 1998a
CAP88-PC: Clean Air Assessment Package
COC: chemical of concern
EPA: U.S. Environmental Protection Agency
FTE: full-time equivalent
hr/day: hours per day
ISCST3: Industrial Source Complex Short-Term Model, Version 3
LCF: latent cancer fatality
L/day: liters per day
m^3/hr: cubic meter per hour
MEI: maximally exposed individual
mg/kg: milligrams per kilogram
mg/kg/day: milligrams per kilogram per day
mg/L: milligrams per liter
mg/m^3: milligrams per cubic meter
mi: miles
mrem: millirem
NCRP: National Council on Radiation Protection and Measurement
OBODM: Open Burn/Open Detonation Model
pCi/L: picocuries per liter
ROI: region of influence
SNL/NM: Sandia National Laboratories/New Mexico
yr: year

for selecting COCs, combined with conservative exposure and intake parameters, captures the potential health risks to receptors. Exposure assessment analyses are explained in Section E.5.4, and final risk results are presented in Section E.6.3.

Annual average exposure point concentrations at receptor locations for each COC were calculated (modeled using the industrial Source Complex Short-term Model, Version 3 [ISCST3]) and presented under the No Action Alternative in Table E.3–2, under the Expanded Operations Alternative (with or without the MESA Complex configuration) in Table E.3–3, and under the Reduced Operations Alternative in Table E.3–4, including chemical exposure point concentrations (per burn day) derived for the Lurance Canyon Burn Site presented in Table E.3–5. The exposure point concentrations for the Lurance Canyon Burn Site did not change for each alternative, but rather human health risk varied based on the number of burns per year (see Appendix D, Section D.1).

The list of COCs varied slightly among the alternatives due to results of the chemical screening process. Under each alternative, specific quantities of each chemical were estimated and emissions were projected. Emissions of smaller amounts of chemicals under the Reduced Operations Alternative eliminated some of the COCs, because they no longer exceeded the screening threshold.

In addition to calculating health risk at each receptor location, maximum chemical exposures to the public and noninvolved worker were calculated. The maximum annual average concentrations of each COC were estimated (using *ISCST3*) for the human health risk assessment. These highest concentrations potentially occurring at the nearest SNL/NM boundary to the source were summed, even though these maximum locations varied. This “hypothetical worst-case” exposure scenario was used to provide a perspective on an upper-bound health risk from chemicals for members of the public. Concentrations at the center of TA-I were considered the worst concentrations that could expose the onsite noninvolved worker. The noninvolved worker risk was based on an 8-hour work day, whereas risk to the hypothetical offsite worst-case member of the public used a 24-hour residential exposure scenario.

Lurance Canyon Burn Site air quality data were evaluated and discussed in Appendix D, Section D.1. Of the 89 chemicals detected from open burning activities, those with dose-response information were used in the assessment of potential human health impacts. The exposure point concentrations presented in Table E.3–5 were associated with open burning activities and used to assess health risk at the Four Hills Subdivision receptor location. Because these concentrations were modeled to the nearest site boundary to the burn site, actual risk at the specified receptor location in the Four Hills Subdivision area would be lower.

SNL/NM also has ambient air volatile organic compound (VOC) monitoring information available. This information was used in a presentation of health

Table E.3–2. Average Annual Concentrations (mg/m^3) of Chemicals of Concern at Selected Public Receptors – No Action Alternative

CHEMICALS OF CONCERN	BUILDING SOURCE	MAXIMUM OFFSITE CONCENTRATION[a]	CENTER OF TA-I[b]	CHILD DEVELOPMENT CENTER-EAST	CHILD DEVELOPMENT CENTER-WEST	CORONADO CLUB	GOLF COURSE	KIRTLAND ELEMENTARY SCHOOL	KAFB HOUSING (Zia Park Housing)	KUMMSC	LOVELACE HOSPITAL
1,2-Dichloroethane (Ethylene Dichloride)	893	9.85×10^{-7}	2.36×10^{-6}	5.09×10^{-8}	1.10×10^{-8}	7.84×10^{-8}	2.08×10^{-8}	1.13×10^{-8}	6.52×10^{-8}	1.36×10^{-8}	1.80×10^{-8}
1,4-Dichloro-2-butene	897	1.68×10^{-7}	1.84×10^{-7}	4.05×10^{-9}	9.36×10^{-10}	4.77×10^{-9}	2.87×10^{-9}	9.31×10^{-10}	3.67×10^{-9}	1.88×10^{-9}	1.41×10^{-9}
Acrylonitrile	897	2.74×10^{-7}	3.00×10^{-7}	6.59×10^{-9}	1.53×10^{-9}	7.77×10^{-9}	4.68×10^{-9}	1.52×10^{-9}	5.99×10^{-9}	3.06×10^{-9}	2.29×10^{-9}
Trichloromethane (Chloroform)	897 6580	1.10×10^{-5}	9.98×10^{-6}	1.35×10^{-7}	3.85×10^{-8}	1.56×10^{-7}	1.84×10^{-7}	3.79×10^{-8}	1.28×10^{-7}	1.67×10^{-7}	5.52×10^{-8}
Dichloromethane (Methylene chloride)	878 870	2.18×10^{-4}	2.95×10^{-4}	7.82×10^{-6}	1.62×10^{-6}	9.43×10^{-6}	4.28×10^{-6}	1.63×10^{-6}	5.51×10^{-6}	2.64×10^{-6}	2.58×10^{-6}
Formaldehyde	878	4.88×10^{-7}	1.05×10^{-6}	2.96×10^{-8}	6.14×10^{-9}	4.08×10^{-8}	1.16×10^{-8}	6.39×10^{-9}	3.75×10^{-8}	7.60×10^{-9}	1.05×10^{-8}
Trichloroethylene	878 897	4.61×10^{-5}	9.21×10^{-5}	2.54×10^{-6}	5.31×10^{-7}	3.46×10^{-6}	1.05×10^{-6}	5.51×10^{-7}	3.15×10^{-6}	6.87×10^{-7}	9.01×10^{-7}

Table E.3–2. Average Annual Concentrations (mg/m³) of Chemicals of Concern at Selected Public Receptors – No Action Alternative (concluded)

CHEMICALS OF CONCERN	BUILDING SOURCE	NATIONAL ATOMIC MUSEUM	RIDING STABLES	SANDIA BASE ELEMENTARY	SHANDIIN DAY CARE CENTER	ISLETA GPAMING PALACE	VETERANS AFFAIRS MEDICAL CENTER	WHERRY ELEMENTARY SCHOOL
1,2-Dichloroethane (Ethylene Dichloride)	893	2.18×10^{-7}	1.29×10^{-8}	5.31×10^{-8}	1.04×10^{-7}	1.87×10^{-8}	2.31×10^{-8}	4.21×10^{-8}
1,4-Dichloro-2-butene	897	7.21×10^{-9}	1.73×10^{-9}	4.46×10^{-9}	4.89×10^{-9}	2.58×10^{-9}	1.66×10^{-9}	3.05×10^{-9}
Acrylonitrile	897	1.17×10^{-8}	2.82×10^{-9}	7.27×10^{-9}	7.97×10^{-9}	4.21×10^{-9}	2.71×10^{-9}	4.97×10^{-9}
Trichloromethane (Chloroform)	897 6580	2.33×10^{-7}	9.46×10^{-8}	1.45×10^{-7}	1.64×10^{-7}	1.65×10^{-7}	6.32×10^{-8}	1.06×10^{-7}
Dichloromethane (Methylene chloride)	878 870	1.71×10^{-5}	2.69×10^{-6}	8.60×10^{-6}	1.07×10^{-5}	3.85×10^{-6}	3.09×10^{-6}	5.71×10^{-6}
Formaldehyde	878	1.22×10^{-7}	7.61×10^{-9}	4.00×10^{-8}	5.95×10^{-8}	1.05×10^{-8}	1.37×10^{-8}	2.17×10^{-8}
Trichloroethylene	878 897	1.01×10^{-5}	6.82×10^{-7}	3.39×10^{-6}	4.97×10^{-6}	9.45×10^{-7}	1.16×10^{-6}	1.87×10^{-6}

Source: EPA 1995a
ITSCST3: Industrial Source Complex Short-Term Model, Version 3
KAFB: Kirtland Air Force Base
KUMMSC: Kirtland Underground Munitions and Maintenance Storage Complex
mg/m³: milligrams per cubic meter

TA: technical area
[a] These concentrations are the maximum offsite concentrations used to evaluate the hypothetical worst-case exposure scenario to the public.
[b] These concentrations are used to represent potential maximum onsite concentrations to evaluate risk to noninvolved workers.
Note: Calculations were made using *ISCST3*, then converted to annual dose average in mg/m³.

Table E.3–3 Average Annual Concentrations (mg/m³) of Chemicals of Concern at Selected Public Receptors – Expanded Operations Alternative

CHEMICALS OF CONCERN	BUILDING SOURCE	MAXIMUM OFFSITE CONCENTRATION[a]	CENTER OF TA-I[b]	CHILD DEVELOPMENT CENTER-EAST	CHILD DEVELOPMENT CENTER-WEST	CORONADO CLUB	GOLF COURSE	KIRTLAND ELEMENTARY SCHOOL	KAFB HOUSING (Zia Park Housing	KUMMSC	LOVELACE HOSPITAL
1,2-Dichloroethane (Ethylene dichloride)[c]	893	1.97×10^{-6}	4.70×10^{-6}	1.02×10^{-7}	2.20×10^{-8}	1.56×10^{-7}	4.14×10^{-8}	2.26×10^{-8}	1.30×10^{-7}	2.72×10^{-8}	3.60×10^{-8}
1,4-Dichloro-2-butene	897	1.68×10^{-7}	1.84×10^{-7}	4.05×10^{-9}	9.36×10^{-10}	4.77×10^{-9}	2.87×10^{-9}	9.31×10^{-10}	3.67×10^{-9}	1.88×10^{-9}	1.41×10^{-9}
Acrylonitrile	897	2.74×10^{-7}	3.00×10^{-7}	6.59×10^{-9}	1.53×10^{-9}	7.77×10^{-9}	4.68×10^{-9}	1.52×10^{-9}	5.99×10^{-9}	3.06×10^{-9}	2.29×10^{-9}
Trichloromethane (Chloroform)	897 6580	9.48×10^{-6}	8.87×10^{-6}	1.32×10^{-7}	3.59×10^{-8}	1.53×10^{-7}	1.59×10^{-7}	3.54×10^{-8}	1.23×10^{-7}	1.39×10^{-7}	5.20×10^{-8}
Dichloromethane (Methylene chloride)	878 870	2.20×10^{-4}	3.01×10^{-4}	7.97×10^{-6}	1.65×10^{-6}	9.64×10^{-6}	4.34×10^{-6}	1.66×10^{-6}	7.71×10^{-6}	2.68×10^{-6}	2.64×10^{-6}
Formaldehyde	878	6.49×10^{-7}	1.40×10^{-6}	3.94×10^{-8}	8.18×10^{-9}	5.43×10^{-8}	1.55×10^{-8}	8.51×10^{-9}	4.99×10^{-8}	1.01×10^{-8}	1.40×10^{-8}
Trichloroethylene	878 897	5.91×10^{-5}	1.20×10^{4}	3.33×10^{-6}	6.95×10^{-7}	4.55×10^{-6}	1.36×10^{-6}	7.21×10^{-7}	4.15×10^{-6}	8.89×10^{-7}	1.18×10^{-6}

Table E.3–3 Average Annual Concentrations (mg/m³) of Chemicals of Concern at Selected Public Receptors – Expanded Operations Alternative (concluded)

CHEMICALS OF CONCERN	BUILDING SOURCE	NATIONAL ATOMIC MUSEUM	RIDING STABLES	SANDIA BASE ELEMENTARY	SHANDIIN DAY CARE CENTER	ISLETA GAMING PALACE	VETERANS AFFAIRS MEDICAL CENTER	WHERRY ELEMENTARY SCHOOL
1,2-Dichloroethane (Ethylene Dichloride)[c]	893	$4.36x10^{-7}$	$2.57x10^{-8}$	$1.06x10^{-7}$	$2.08x10^{-7}$	$3.73x10^{-8}$	$4.61x10^{-8}$	$8.40x10^{-8}$
1,4-Dichloro-2-butene	897	$7.21x10^{-9}$	$1.73x10^{-9}$	$4.46x10^{-9}$	$4.89x10^{-9}$	$2.58x10^{-9}$	$1.66x10^{-9}$	$3.05x10^{9}$
Acrylonitrile	897	$1.17x10^{-8}$	$2.82x10^{-9}$	$7.27x10^{-9}$	$7.97x10^{-9}$	$4.21x10^{-9}$	$2.71x10^{-9}$	$4.97x10^{-9}$
Trichloromethane (Chloroform)	897 6580	$2.29x10^{-7}$	$8.40x10^{-8}$	$1.42x10^{-7}$	$1.60x10^{-7}$	$1.44x10^{-7}$	$5.99x10^{-8}$	$1.03x10^{-7}$
Dichloromethane (Methylene chloride)	878 870	$1.77x10^{-5}$	$2.73x10^{-6}$	$8.81x10^{-6}$	$1.10x10^{-5}$	$3.91x10^{-6}$	$3.16x10^{-6}$	$5.83x10^{-6}$
Formaldehyde	878	$1.62x10^{-7}$	$1.01x10^{-8}$	$5.33x10^{-8}$	$7.92x10^{-8}$	$1.39x10^{-8}$	$1.82x10^{-8}$	$2.89x10^{-8}$
Trichloroethylene	878 897	$1.33x10^{-5}$	$8.84x10^{-7}$	$4.46x10^{6}$	$6.55x10^{-6}$	$1.22x10^{-6}$	$1.53x10^{-6}$	$2.45x10^{-6}$

Source: EPA 1995a
ITSCST3: Industrial Source Complex Short-Term Model, Version 3
KAFB: Kirtland Air Force Base
KUMMSC: Kirtland Underground Munitions and Maintenance Storage Complex
mg/m³: milligrams per cubic meter
TA: technical area
[a] These concentrations are the maximum offsite concentrations used to evaluate the hypothetical worst-case exposure scenario to the public.
[b] These concentrations are then used to represent potential maximum onsite concentrations used to evaluate risk to noninvolved workers.
[c] If implemented for the Microsystems and Engineering Sciences Applications (MESA) Complex configuration for the Expanded Operations Alternative, this chemical of concern would no longer exist at the MESA Complex and would no longer fail the screening process.
Note: Calculations were made using *ISCST3*, then converted to annual average in mg/m³.

Table E.3–4 Average Annual Concentrations (mg/m³) of Chemicals of Concern at Selected Public Receptors – Reduced Operations Alternative

CHEMICALS OF CONCERN	BUILDING SOURCE	MAXIMUM OFFSITE CONCENTRATION[a]	CENTER OF TA-I[b]	CHILD DEVELOPMENT CENTER-EAST	CHILD DEVELOPMENT CENTER-WEST	CORONADO CLUB	GOLF COURSE	KIRTLAND ELEMENTARY SCHOOL	KAFB HOUSING (Zia Park Housing)	KUMMSC	LOVELACE HOSPITAL
1,2-Dichloroethane (Ethylene Dichloride)	893	7.05×10^{-7}	2.36×10^{-6}	1.27×10^{-8}	2.31×10^{-9}	1.96×10^{-8}	2.86×10^{-9}	2.10×10^{-9}	1.32×10^{-8}	2.21×10^{-9}	3.98×10^{-9}
1,4-Dichloro-2-butene	897	2.04×10^{-7}	1.69×10^{-7}	3.47×10^{-9}	7.54×10^{-10}	4.03×10^{-9}	1.56×10^{-9}	5.84×10^{-10}	2.48×10^{-9}	1.68×10^{-9}	1.26×10^{-9}
Acrylonitrile	897	3.33×10^{-7}	2.76×10^{-7}	5.65×10^{-9}	1.23×10^{-9}	6.57×10^{-9}	2.53×10^{-9}	9.51×10^{10}	4.04×10^{-9}	2.74×10^{-9}	2.04×10^{-9}
Formaldehyde	878	$3.24 \mathrm{X} 10^{-7}$	7.03×10^{-7}	1.97×10^{-8}	2.84×10^{-9}	2.72×10^{-8}	4.40×10^{-9}	3.09×10^{-9}	1.78×10^{-8}	3.04×10^{-9}	4.92×10^{-9}
Dichloromethane (Methylene Chloride)	870	3.21×10^{-4}	2.80×10^{-4}	7.39×10^{-6}	1.38×10^{-6}	8.22×10^{-6}	2.39×10^{-6}	1.03×10^{-6}	4.90×10^{-6}	1.66×10^{-6}	2.30×10^{-6}
Trichloroethylene	878 897	3.45×10^{-5}	6.34×10^{-5}	1.73×10^{-6}	2.59×10^{-7}	2.35×10^{-6}	4.17×10^{-7}	2.72×10^{-7}	1.53×10^{-6}	3.14×10^{-7}	4.46×10^{-7}

Table E.3–4 Average Annual Concentrations (mg/m³) of Chemicals of Concern at Selected Public Receptors – Reduced Operations Alternative (concluded)

CHEMICALS OF CONCERN	BUILDING SOURCE	NATIONAL ATOMIC MUSEUM	RIDING STABLES	SANDIA BASE ELEMENTARY	SHANDIIN DAY CARE CENTER	ISLETA GAMING PALACE	VETERANS AFFAIRS MEDICAL CENTER	WHERRY ELEMENTARY SCHOOL
1,2-Dichloroethane (Ethylene Dichloride)	893	3.79×10^{-8}	1.82×10^{-9}	1.53×10^{-8}	1.98×10^{-8}	2.58×10^{-9}	4.50×10^{-9}	1.05×10^{-8}
1,4-Dichloro-2-butene	897	6.19×10^{-9}	7.85×10^{-10}	4.51×10^{-9}	3.60×10^{-9}	1.40×10^{-9}	1.13×10^{-9}	2.63×10^{-9}
Acrylonitrile	897	1.01×10^{-8}	1.28×10^{-9}	7.34×10^{-9}	5.86×10^{-9}	2.28×10^{-9}	1.83×10^{-9}	4.28×10^{-9}
Formaldehyde	878	5.52×10^{-8}	2.65×10^{-9}	3.11×10^{-8}	2.72×10^{-8}	3.96×10^{-9}	6.81×10^{-9}	1.36×10^{-8}
Dichloromethane (Methylene Chloride)	870	1.43×10^{-5}	1.32×10^{-6}	1.08×10^{-5}	7.29×10^{-6}	2.15×10^{-6}	2.03×10^{-6}	5.29×10^{-6}
Trichloroethylene	878	4.68×10^{-6}	2.45×10^{-7}	2.68×10^{-6}	2.32×10^{-6}	3.76×10^{-7}	5.92×10^{-7}	1.19×10^{-6}

Source: EPA 1995a
ITSCST3: Industrial Source Complex Short-Term Model, Version 3
KAFB: Kirtland Air Force Base
KUMMSC: Kirtland Underground Munitions and Maintenance Storage Complex
mg/m³: milligrams per cubic meter
TA: technical area

[a] These concentrations are the maximum offsite concentrations used to evaluate the hypothetical worst-case exposure scenario to the public.
[b] These concentrations are the used to represent potential maximum onsite concentrations used to evaluate risk to noninvolved workers.
Note: Calculations were made using *ISCST3*, then converted to annual average in mg/m³.

Table E.3–5. Chemicals of Concern Exposure Point Concentrations from the Lurance Canyon Burn Site used for Health Risk Analysis Under Each Alternative[a]

CHEMICALS OF CONCERN	CONCENTRATION[b] (mg/m^3)
1,1,2-Trichloroethane	4.95×10^{-8}
1,2,4-Trichlorobenzene	1.68×10^{-6}
1,2,4-Trimethylbenzene	1.17×10^{-7}
1,2-Dichloroethane	2.93×10^{-9}
1,2-Dichloropropane	2.10×10^{-10}
1,3,5-Trimethylbenzene	2.26×10^{-8}
1, 3-Butadiene	2.01×10^{-7}
2-Butanone	3.35×10^{-9}
Acetaldehyde	5.45×10^{-9}
Benzene	1.68×10^{-6}
Bis(Chloroethyl)ether	4.19×10^{-9}
Chloromethane	1.26×10^{-9}
Dichlorodifluromethane	7.88×10^{-9}
Ethylbenzene	2.93×10^{-7}
Hexachloro-1,3-butadiene	1.93×10^{-9}
Hexane (n)	5.70×10^{-9}
Dichloromethane (methylene chloride)	1.01×10^{-10}
Methyl Isobutyl Ketone	7.04×10^{-9}
Methylcyclohexane	7.46×10^{-8}
Styrene	2.43×10^{-7}
Toluene	2.77×10^{-7}
Trichloroethylene	2.60×10^{-9}
Vinyl Chloride	1.84×10^{-8}

Source: EPA 1995a
mg/m^3: milligrams per cubic meter
$\mu g/m^3$: micrograms per cubic meter
EPA: U.S. Environmental Protection Agency
Note: Eighty-nine chemicals are known to be released in small quantities from the burning of JP-8 fuel. Only those with EPA reference doses are used in the calculation of health risk.
[a] Concentrations used in health risk analysis for the Four Hills Subdivision receptor location. Concentrations remain constant. The number of burns per year are 10 for the No Action Alternative, 58 for the Expanded Operations Alternative, and 5 for the Reduced Operations Alternative. If implemented, the Microsystems and Engineering Sciences Applications (MESA) Complex configuration would not change the number of burns per year for the Expanded Operations Alternative.
[b] Annual average air concentrations (in mg/m^3) used in health risk analysis derived from Table D.1–31, 8-hour average concentration in $\mu g/m^3$ from the burning of 1,000 gal of JP-8.

risks, because it provides some perspective on this topic and is derived from actual environmental concentrations. Because these environmental data cannot be tied to SNL/NM only, the information is presented in the cumulative impacts section. Maximum concentrations of chemicals detected by SNL/NM ambient air VOC monitoring stations in 1996 were used for assessing cumulative human health impacts (Table E.3–6). A long-term exposure scenario, using these exposure point concentrations, results in a conservative estimate of potential cumulative human health impacts in the SNL/NM vicinity, because the maximum concentrations were actually detected at different monitoring stations and during different monitoring times throughout 1996 (SNL 1997d).

Table E.3–6. Maximum Air Concentrations of Chemicals Detected by SNL/NM Volatile Organic Compound Monitoring Stations used to Assess Cumulative Human Health Impacts

CHEMICALS OF CONCERN	CONCENTRATION[a] (mg/m^3)
Benzene	3.57×10^{-4}
Carbon tetrachloride	1.50×10^{-4}
Chloromethane	1.91×10^{-4}
Dichlorodifluoromethane	6.22×10^{-4}
Dichloromethane	5.98×10^{-4}
Ethylbenzene	1.19×10^{-4}
n-Hexane	1.95×10^{-4}
Tetrachloroethene	5.70×10^{-5}
Toluene	7.83×10^{-4}
1,1,1-Trichloroethane	4.88×10^{-2}
Trichloroethylene	1.31×10^{-4}
Trichlorofluoromethane	3.11×10^{-4}

Source: SNL 1997d
mg/m^3: milligrams per cubic meter
$\mu g/m^3$: micrograms per cubic meter
EPA: U.S. Environmental Protection Agency
VOC: volatile organic compound
SNL/NM: Sandia National Laboratories/New Mexico
[a] Maximum annual average air concentrations (in mg/m^3) derived from data in Table 4.9–4, from 8-hour average concentrations in $\mu g/m^3$.
Note: Thirty VOCs were detected by SNL/NM VOC monitoring stations. This table contains only those with EPA reference dose values that can be used in the health risk analysis.

E.4 TOXICITY ASSESSMENT

The purpose of the toxicity assessment dose response is to identify the potential adverse health effects a COC may cause and to define the relationship between the dose of a COC and the likelihood and/or magnitude of an adverse effect (response). For the risk assessment process, the EPA characterizes adverse effects as carcinogenic or noncarcinogenic (potential effects other than cancer). Dose-response relationships are defined by the EPA for oral exposure and for exposure by inhalation. Oral dose-response values are also used for dermal exposures because the EPA has not yet developed values for this route of exposure. Combining the results of the dose-response assessment with information on the magnitude of potential human exposure provides an estimate, usually very conservative, of potential risk. Current dose-response values developed by the EPA are used in this risk assessment.

Section 4.1 describes the EPA's approach for developing noncarcinogenic dose-response values. Section 4.2 describes the carcinogenic dose-response relationships developed by the EPA. Sources of the published dose-response values used in this risk assessment include the EPA's Integrated Risk Information System (IRIS) (EPA 1998a), the Health Effects Assessment Summary Tables (HEAST) (EPA 1997b), and the EPA National Center for Environmental Assessment (NCEA, formerly ECAO) (NCEA 1998).

E.4.1 Toxicity Information for Noncarcinogenic Effects

Compounds with known or potential noncarcinogenic effects are assumed to have a dose below which no adverse effect occurs or, conversely, above which an adverse effect may be seen. This dose is called the threshold dose. An estimate of the true threshold dose is called a No Observed Adverse Effect Level (NOAEL). The lowest dose at which an adverse effect occurs is called a Lowest Observed Adverse Effect Level (LOAEL). By applying uncertainty factors to the NOAEL or the LOAEL, RfDs for subchronic and chronic exposures to chemicals with noncarcinogenic effects have been developed by the EPA. The uncertainty factors account for uncertainties associated with the dose-response relationship such as the effects of using an animal study to derive a human dose-response value, extrapolating from high to low doses, and evaluating sensitive subpopulations. Generally, a 10-fold factor is used to account for each of these uncertainties; thus, the total uncertainty factor can range from 10 to 10,000. In addition, an uncertainty factor or modifying factor of up to 10 can be used to account for "inadequacies in the database." For chemicals with noncarcinogenic effects, an RfD provides reasonable certainty that no noncarcinogenic health effects are expected to occur even if daily exposures were to occur at the RfD level for a lifetime. RfDs and exposure doses are expressed in units of milligrams of chemical per kilogram body weight per day (mg/kg-day).

The dose-response information for the COCs with potential noncarcinogenic effects for the inhalation route of exposure is summarized in Tables E.4–1 and E.4–2. For each chemical, the chemical abstract system (CAS) number, the chronic dose-response value, and the reference for the dose-response value are presented.

E.4.2 Toxicity Information for Carcinogenic Effects

The underlying regulatory assumption for risk assessment for compounds with known potential carcinogenic effects is that no threshold dose exists. In other words, the compound has the potential to cause cancer at any level of exposure. This assumption requires that risk characterization evaluates finite levels of risk associated with each non-zero dose. The EPA extrapolates dose-response relationships observed at the relatively high doses used in animal studies to the low dose levels encountered by humans in environmental situations. For carcinogenic effects, human data relating chemical exposure to a specific cancer response are rare. More frequently, animal toxicological data are available. The mathematical models assume no threshold and use both animal and human data (where available) to develop a potency estimate for a given compound. The potency estimate, called a cancer slope factor (CSF) is expressed in units of $(mg/kg\text{-}day)^{-1}$. For the inhalation pathway, the CSF can be expressed as an air concentration factor called the unit risk factor.

Tables E. 4–3 and E. 4–4 summarize the inhalation dose-response information developed by the EPA for potentially carcinogenic COCs identified at the SNL/NM site. The tables provide the CAS number, the CSF, the unit risk factor, and a reference for each chemical. A chemical can have both carcinogenic and noncarcinogenic impacts. Carcinogenic impacts generally have a higher overall risk than noncarcinogenic risks, and, although both types of risks cannot be compared directly, action levels for cancer-causing compounds are generally lower.

Table E.4–1. Dose-Response Information for Potential Noncarcinogenic Chemicals of Concern from Facilities

CHEMICALS OF CONCERN	CAS NUMBER	INHALATION RfD (mg/kg-day)	REFERENCE
1,2-Dichloroethane	107-06-2	1.40×10^{-3}	NCEA 1998
1,4-Dichloro-2-butene	764-41-0	NA	IRIS (EPA 1998a)
Acrylonitrile	107-13-1	5.71×10^{-4}	IRIS (EPA 1998a); HEAST (EPA 1997b)
Trichloromethane (chloroform)	67-66-3	8.60×10^{-5}	IRIS (EPA 1998a)
Dichloromethane (methylene chloride)	75-09-2	8.57×10^{-1}	EPA (EPA 1998a)
Formaldehyde	50-00-0	NA	IRIS (EPA 1998a)
Trichloroethylene	79-01-6	NA	IRIS (EPA 1998a)

Sources: EPA 1997b, 1998a; NCEA 1998
CAS: Chemical Abstract Service
IRIS: Integrated Risk Information System, an online computer database of toxicological information (EPA 1998a)
HEAST: Health Effects Assessment Summary Tables, published annually by the EPA (EPA 1997b)
mg/kg-day: milligrams per kilogram per day
NA: Not applicable; no noncarcinogenic dose-response information
NCEA: National Center for Environmental Assessment (formerly ECAO) (NCEA 1998)
RfD: reference dose

Table E.4–2. Dose-Response Information for Potential Noncarcinogenic Chemicals of Concern from Lurance Canyon Burn Site

CHEMICALS OF CONCERN	CAS NUMBER	EPA CARCINOGEN CLASS	INHALATION CSF $(mg/kg\text{-}day)^{-1}$	INHALATION UNIT RISK $(\mu g/m^3)^{-1}$	REFERENCE
1,2 - Dichloroethane	107-06-2	B2	9.10×10^{-2}	2.6×10^{-5}	IRIS (EPA 1998a)
1,4-Dichloro-2-butene	764-41-0	NF	9.30	2.66×10^{-3}	IRIS (EPA 1998a)
Acrylonitrile	107-13-1	B1	2.38×10^{-1}	6.80×10^{-5}	IRIS (EPA 1998a)
Trichloromethane (chloroform)	67-66-3	B2	8.05×10^{-2}	2.3×10^{-5}	IRIS (EPA 1998a)
Dichloromethane (methylene chloride)	75-09-2	B2	1.65×10^{-3}	4.70×10^{-7}	IRIS (EPA 1998a)
Formaldehyde	50-00-0	B1	4.55×10^{-2}	1.3×10^{-5}	IRIS (EPA 1998a)
Trichloroethylene	79-01-6	B2-C	6.00×10^{-3}	1.71×10^{-6}	NCEA 1998

Sources: EPA 1997b, 1998a; NCEA 1998
CAS: Chemical Abstracts Service
CSF: Cancer Slope Factor
EPA: U.S. Environmental Protection Agency
HEAST: Health Effects Assessment Summary Tables, published annually by the EPA (EPA 1997b)
IRIS: Integrated Risk Information System, an online computer database of toxicological information (EPA 1998a)
mg/kg-day: milligrams per kilogram per day
NA: Not Applicable, no noncarcinogenic dose response information
NCEA: National Center for Environmental Assessment (formerly ECAO) (NCEA 1998).

Table E.4–3. Dose-Response Information for Potential Carcinogenic Chemicals of Concern from Facilities

CHEMICALS OF CONCERN	CAS NUMBER	EPA CARCINOGEN CLASS	INHALATION CSF $(mg/kg\text{-}day)^{-1}$	INHALATION UNIT RISK $(\mu g/m^3)^{-1}$	REFERENCE
1,2 - Dichloroethane	107-06-2	B2	$9.10x10^{-2}$	$2.6x10^{-5}$	IRIS (EPA 1998a)
1,4-Dichloro-2-butene	764-41-0	NF	9.30	$2.66x10^{-3}$	IRIS (EPA 1998a)
Acrylonitrile	107-13-1	B1	$2.38x10^{-1}$	$6.80x10^{-5}$	IRIS (EPA 1998a)
Trichloromethane (chloroform)	67-66-3	B2	$8.05x10^{-2}$	$2.3x10^{-5}$	IRIS (EPA 1998a)
Dichloromethane (methylene chloride)	75-09-2	B2	$1.65x10^{-3}$	$4.70x10^{-7}$	IRIS (EPA 1998a)
Formaldehyde	50-00-0	B1	$4.55x10^{-2}$	$1.3x10^{-5}$	IRIS (EPA 1998a)
Trichloroethylene	79-01-6	B2-C	$6.00x10^{-3}$	$1.71x10^{-6}$	NCEA 1998

Sources: EPA 1997b, 1998a; NCEA 1998
CAS: Chemical Abstracts Service
CSF: Cancer Slope Factor
EPA: U.S. Environmental Protection Agency

IRIS: Integrated Risk Information System, an online computer database of toxicological information (EPA 1998a).
NCEA: National Center for Environmental Assessment (formerly ECAO) (NCEA 1998).
mg/kg-day: milligrams per kilogram per day
$\mu g/m^3$: micrograms per cubic meter
NF: not found

Table E.4–4. Dose-Response Information for Potential Carcinogenic Chemicals of Concern from Lurance Canyon Burn Site

CHEMICALS OF CONCERN	CAS NUMBER	EPA CARCINOGEN CLASS	INHALATION CSF $(mg/kg\text{-}day)^{-1}$	REFERENCE
1,1,2-Trichloroethane	79-00-5	C	$5.6x10^{-2}$	IRIS (EPA 1998a)
1,2-Dichloroethane	107-06-2	B2	$9.10x10^{-2}$	NCEA 1998
1,2-Dichloropropane	78-87-5	NA	NA	IRIS (EPA 1998a)
1,2,4 Trichlorobenzene	120-82-1	NA	NA	IRIS (EPA 1998a)
1,2,4-Trimethylbenzene	95-63-6	NA	NA	NCEA 1998
1,3 - Butadiene	106-99-0	B2	$9.8x10^{-1}$	IRIS (EPA 1998a)
1,3,5-Trimethylbenzene	108-67-8	NA	NA	IRIS (EPA 1998a)
Acetaldehyde	75-07-0	B2	$7.7x10^{-3}$	IRIS (EPA 1998a)
Benzene	71-43-2	A	$2.9x10^{-2}$	IRIS (EPA 1998a)
Bis (2-chloroethyl) ether	111-44-4	B2	1.16	IRIS (EPA 1998a)
Chloromethane	74-87-3	D	$6.3x10^{-3}$	HEAST (EPA 1997b)
Dichlorodifluoromethane	75-71-8	NA	NA	IRIS (EPA 1998a)
Dichloromethane (methylene chloride)	75-09-2	B2	$1.65x10^{-3}$	IRIS (EPA 1998a); HEAST (EPA 1997b)
Ethylbenzene	100-41-4	NA	NA	IRIS (EPA 1998a)
Hexachlorobutadiene	87-68-3	C	$7.8x10^{-2}$	IRIS (EPA 1998a)
Hexane (n)	110-54-3	NA	NA	IRIS (EPA 1998a)
2-butanone	78-93-3	NA	NA	IRIS (EPA 1998a)
Methyl Isobutyl Ketone	108-10-1	NA	NA	IRIS (EPA 1998a)
Methlycyclohexane	108-87-2	NA	NA	IRIS (EPA 1998a)
Styrene	100-42-5	NA	NA	IRIS (EPA 1998a)

Table E.4–4. Dose-Response Information for Potential Carcinogenic Chemicals of Concern from Lurance Canyon Burn Site (concluded)

CHEMICALS OF CONCERN	CAS NUMBER	EPA CARCINOGEN CLASS	INHALATION CSF $(mg/kg\text{-}day)^{-1}$	REFERENCE
Toluene	108-88-3	NA	NA	IRIS (EPA 1998a)
Trichloroethylene	79-01-6	B2-C	6.00×10^{-3}	NCEA 1998
Vinyl Chloride	75-01-4	A	3.0×10^{-1}	HEAST (EPA 1997b)

Sources: EPA 1997b, 1998a; NCEA 1998
CAS: Chemical Abstracts Service
CSF: Cancer Slope Factor
EPA: U.S. Environmental Protection Agency
HEAST: Health Effects Assessment Summary Tables, published annually by the EPA (EPA 1997b)
IRIS: Integrated Risk Information System, an online computer database of toxicological information (EPA 1998a)
mg/kg-day: milligrams per kilogram per day
NA: Not Applicable, no noncarcinogenic dose response information
NCEA: National Center for Environmental Assessment (formerly ECAO) (NCEA 1998).
$\mu g/m^3$: micrograms per cubic meter
Note: No chemical screening was done for chemicals from burn activities; all chemicals with EPA dose-response information are evaluated.

E.5 EXPOSURE ASSESSMENT

E.5.1 Exposure Setting (Current and Potential Future Operating Levels)

Chapter 2 of the SWEIS described the operating levels for SNL/NM used to analyze environmental impacts. This information provided the basis for determining the levels of subsequent risks to human health from those impacts. The *SNL/NM Facility and Safety Information Document* also contains descriptions of operating levels for selected facilities (SNL/NM 1998a).

If implemented, the MESA Complex configuration was considered in the exposure setting for the Expanded Operations Alternative as identified in the text and corresponding tables.

E.5.2 Exposure Pathways

An exposure pathway must be complete in order to be evaluated for health risk. This means that an environmental contaminant must be present at the receptor location to be considered a complete exposure pathway. Health effects were evaluated for each alternative only for those transport pathways determined to represent the major exposure pathways. The following measurement endpoints were assessed:

- estimates of noncancer health risk from potential exposures to routine noncarcinogenic chemical releases based on predicted exposure-point concentrations from air emissions and air quality;
- estimates of excess lifetime cancer risk to an individual from carcinogenic chemical releases based on predicted exposure-point concentrations from air emissions and air quality;
- total number of LCFs in the ROI population and increased risk of fatal cancer to an individual from potential exposures to routine radiological releases based on predicted exposure-point concentrations from air emissions and air quality;
- total number of nonfatal cancers and genetic disorders from potential exposures to routine radiation releases based on predicted exposure-point concentrations from air emissions and air quality;
- total number of LCFs in the ROI population due to exposure from the transportation of radiological materials;
- estimates of the number of physical injuries/illnesses based on the total number of workers under each alternative and the 5-year average injury/illness rate derived for SNL/NM (1992-1996);
- estimates of workers' increased lifetime risk of fatal cancer from radiological exposures based on the total number of radiation workers extrapolated from changes in the total number of workers under each alternative, multiplied by the historic (average for 1992-1996) SNL/NM radiation worker dose rates; and
- the pathways determined not to expose people, including groundwater, surface water, and soils/dust (see Sections 5.3.3, 5.4.3, 5.5.3, and Appendix B).

E.5.3 Receptor Characterization

Sixteen core receptor locations were consistent among the evaluations for impacts due to routine operations, chemical and radiological emissions, and potential facility accidents at SNL/NM. These receptor locations were selected based on a review of historic National Emissions Standards for Hazardous Air Pollutants (NESHAP) compliance reports, which discuss the location of the MEI member of public and take into consideration that the general public and Air Force personnel have access to SNL/NM. Other factors taken into account include information contained in the *SNL/NM Facility Source Documents* (SNL/NM 1998a), receptor locations in close proximity to the sources, the nearest site boundary in the prevailing wind directions, and the presence of potentially sensitive receptors such as children, the sick, and the elderly. Included are two receptor locations of public concern representing the Four Hills Subdivision and the Isleta Gaming Palace, which are farther away from SNL/NM. These sixteen receptor locations are listed below.

- Child Development Center-East
- Child Development Center-West
- Coronado Club
- Four Hills Subdivision
- Golf Course
- Kirtland Elementary School
- KAFB Housing (Zia Housing)
- Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC)
- Lovelace Hospital

- National Atomic Museum
- Riding Stables
- Sandia Base Elementary School
- Shandiin Day Care Center
- Isleta Gaming Palace
- Veterans Affairs Medical Center (Hospital)
- Wherry Elementary School

In addition to these receptor locations, the specific evaluations of chemical air emissions, radiological air emissions, and facility accidents each included additional receptor locations unique to the needs of the resource area in order to complete their analyses of impacts (see discussions in radiological air, chemical air, and accident analyses).

Chemical receptor locations were selected according to the locations accessible to members of the public in the SNL/NM vicinity (see discussion in Section 5.3.8). Both potential long-term and short-term exposures were considered to cover the range of exposure possibilities (that is, a permanent residence or a visitor scenario, respectively). The EPA has coined the phrase "reasonable maximum exposure" (RME) when general default exposure assumptions are used that tend to fall within the upper 90th confidence interval of the arithmetic mean (statistically upper-bound value of the range). The central tendency or average exposure values would be those that fall within the 50th percentile of the statistical range. Based on statistical averages, average exposure assumptions would be those that would tend to occur most frequently. Therefore, to account for the most plausible type of exposures as well as exposures that may be more frequent or constant than the norm, both the RME and an average exposed individual (AEI) were considered. The presence of potentially special receptors, such as children, at these locations was also considered.

Based on professional judgement, various receptor locations were selected, including the onsite location for noninvolved workers, as the most likely areas where exposures might occur. Because exposure concentrations vary with distance and direction, based on transport by way of the air pathway, the receptor locations selected encompassed a wide range of areas where potential exposures might occur. Limited historical chemical air emissions data prevent the estimation of an MEI location as was done for radiological air releases. Instead, exposure assumptions were determined based on the range of potential exposures (the AEI and RME) that may occur at each location. Table E.5–1 identifies the exposure parameters used to determine the chemical intake for the potential RME and AEI receptors at the selected locations and the hypothetical worst-case exposure scenario.

A hypothetical worst-case residential RME/AEI receptor scenario was included in the exposure assessment that considers exposure to the maximum concentrations that may be considered from any source. This scenario may be distinguished from the other scenarios, because the transport to a given location is not considered, but rather, the maximum air concentration of any given COC is assumed to be inhaled by the RME and AEI hypothetical resident. This exposure scenario was used to estimate an upper-bound potential health risk value under each alternative.

Radiological receptor locations were developed from historic analyses performed as required annually by the *Clean Air Act* (CAA) and NESHAP (Appendix D). Years of data analysis provide a good estimate of the MEI and its location. A subset of the known NESHAP receptor locations was selected to include the highest exposure dose locations, and the same locations were analyzed for chemical exposures.

It is reasonable to assess an individual composite cancer risk using the radiological MEI risk at the KUMMSC and the chemical cancer risk at the same location. To capture the potential highest risk from chemicals, another assessment of an individual composite cancer risk was derived by summing the cancer risk from a hypothetical worst-case chemical exposure scenario and the radiological MEI (KUMMSC) cancer risk. Because this exposure is hypothetical and would not occur, this was a conservative mathematical assessment to provide a bounding of the health risk value. This assessment did not represent a specific receptor location in the SNL/NM vicinity.

E.5.4 Chemical Exposure and Chemical Intake

This section provides the methodology and equations used to calculate potential chemical exposure doses used to assess carcinogenic and noncarcinogenic health risks.

A risk assessment computer application called *SmartRISK* is used to calculate the estimated receptor intake of the COCs (SmartRISK 1996). *SmartRISK* uses the following standard EPA equations (EPA 1989) for calculating the intake of media (soil, water, or air) or the quantity of a medium taken into the body through an exposure route:

Table E.5–1. Exposure Parameters Used to Evaluate Human Health Risk from Chemicals

PARAMETER	AEI VALUE	SOURCE/RATIONALE	RME VALUE	SOURCE/RATIONALE
AIR PATHWAY-SPECIFIC PARAMETERS				
Inhalation Rate (m^3/day)				
Onsite Worker	1.1 (m^3/hr)	Worker involved in light activity [a]	1.5 (m^3/hr)	Average outdoor worker activity [a]
Visitor & Resident:				
Child Age: 1-6	8.7 (m^3/day)	Average daily rate for children [a]	8.7 (m^3/day)	Average daily rate for children [a]
Adult Age: 7-30	15.2 (m^3/day)	Daily adult inhalation rate for long-term exposure[a]	15.2 (m^3/day)	Daily adult inhalation rate for long-term exposure[a]
Inhalation Exposure Time (hours/day)				
Onsite Worker	1 (hours/day)	Assumption	4 (hours/day)	Assumption
Visitor & Resident:				
Child Aged: 1-6	1.75 (hours/day)	50th percentile of time playing outdoors[a]	6.25 (hours/day)	95th percentile of time playing outdoors[a]
Adult Aged: 7-30	1.44 (hours/day)	50th percentile of time spent outdoors[a]	7.25 (hours/day)	95th percentile of time spent outdoors[a]
GENERAL PARAMETERS				
Exposure Frequency (days/year)				
Visitor	40	Typical time spent outdoors [a]	165	School year minus 3 weeks vacation
Onsite Worker	40	Typical time spent outdoors [a]	250	5 days/week for 50 weeks [a]
Resident:				
Child Aged: 1-6	120	6 day/week for 20 weeks [a]	350	7 days/week for 50 weeks [a]
Adult Aged: 7-30	40	2 day/week for 20 weeks [a]	350	7 days/week for 50 weeks [a]
Exposure Duration (years)				
Visitor	1	Assumption	6	Assumption
Onsite Worker	6.6	Median job tenure value [a]	25	Upper range job tenure value [a]
Resident:				
Child Aged: 1-6	6	Child from birth through age 6 [a]	6	Child from birth through age 6 [a]
Adult Aged: 7-30	9	Average length of time at a single residence [a]	24	For combination with child to equal 30 years [a]
Body Weight (kg)				
Onsite Worker	70	Mean weight adult male [a]	70	Mean weight adult male [a]
Visitor & Resident:				
Child Aged: 1-6	15	Mean weight child, age 6 [a]	15	Mean weight child, age 6 [a]
Adult Aged: 7-30	70	Mean weight adult male [a]	70	Mean weight adult male [a]

Source: EPA 1989, 1996a
AEI: average exposed individual
kg: kilogram

m^3: cubic meter
RME: reasonable maximum exposure
[a] Values recommended by the EPA in the *United States Environmental Protection Agency Exposure Factors Handbook 1996*

$$\text{Media Intake (concentration/kg body weight/day)} = \frac{(C \times IR \times EF \times ED)}{(BW \times AT)}$$

(Eq. E.5–1)

Where: C = Concentration within given medium (for example, mg/kg (soil); mg/L (water); or mg/m^3 (air))
IR = Intake Rate (for example, ingestion in mg/day (soil); L/day (water); or inhalation in m^3/day)
EF = Exposure Frequency (days/year)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time (days) (Averaging time is a lifetime for carcinogens and is the exposure duration for noncarcinogens.)

Calculation of chemical intake requires multiplying the media exposure concentration of each chemical by the media intake factor derived for the exposure route. Inadvertent contact with soil or water and exposure to air would require inclusion of the exposure time (ET) (hours/day) in the numerator. Appropriate conversion factors are applied when needed.

The equation for Chronic Daily Intake (CDI) is used to estimate a receptor's potential intake from exposure to a compound with noncarcinogenic effects. According to the EPA, the chemical exposure dose should be calculated by averaging over the period of time for which the receptor is assumed to be exposed (EPA 1989). For compounds with potential carcinogenic effects, however, the equation for Lifetime Average Daily Dose (LADD) for chemicals is employed to estimate potential exposures. In accordance with the EPA, the LADD is calculated by averaging the assumed exposure over the receptor's lifetime. Therefore, in the following formulas for estimating a receptor's average daily dose from chemicals (both lifetime and chronic) only the averaging time (AT) used differs for the calculation of CDI for noncarcinogens versus calculation of the LADD for carcinogens. The chemical intake (CDI and LADD) was expressed as milligrams of chemical per kilogram of body weight per day (m/kg-day).

The following general equation was used for calculating the intake of chemicals through the inhalation exposure route:

$$\underset{\text{(CDI or LADD)}}{\text{Chemical Intake}_i \text{ (mg/kg-day)}} = \frac{C_i \times IR \times ET \times EF \times ED}{BW \times AT}$$

(Eq. E.5–2)

Where: C_i = Air exposure concentration of chemical i (mg/m^3)
IR = Inhalation Rate (m^3/hour)
ET = Exposure Time (hours/day)
EF = Exposure Frequency (days/year)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time (days) (Averaging time is a lifetime for carcinogens and is the exposure duration for noncarcinogens.)

An integrated adult-plus-child risk calculation is used to better estimate chronic exposures over a person's lifetime (SmartRISK 1996). The equation takes into account the timeframe when a child's exposure parameters apply and the timeframe when adult exposure parameters apply. A total of 30 years is the exposure duration for the RME integrated calculation, while a total of 15 years is the exposure duration for the AEI integrated calculation. The integrated risk assessment equation used by *SmartRISK* for inhalation exposure was:

$$\text{Chemical Intake}_i \text{ (mg/kg-day)} = \frac{\dfrac{C_i \times IR_c \times ET_c \times EF_c \times FC_c}{BW_c} \times ED_c + \dfrac{C_i \times IR_a \times ET_a \times EF_a \times FC_a}{BW_a} \times ED_a}{AT_c + AT_a}$$

(Eq. E.5–3)

Where: Ci = Air exposure concentration of chemical i (mg/m^3)
IR_c (c=child) = Inhalation Rate (m^3/hr)
ET = Exposure Time (hours/day)
EF_c = Exposure Frequency (days/year)
FC_c = Fraction from Contaminated Source
BW_c = Body Weight (kg)
ED_c = Exposure Duration (years)
AT_c = Averaging Time (days) (Averaged over a lifetime for carcinogens or the exposure duration for noncarcinogens.)
IR_a (a=adult) = Inhalation Rate (m^3/hour)

ET_a = Exposure Time (hours/day)
EF_a = Exposure Frequency (days/year)
FC_a = Fraction from Contaminated Source
BW_a = Body Weight (kg)
ED_a = Exposure Duration (years)
AT_a = Averaging Time (days) (Averaged over a lifetime for carcinogens or the exposure duration for noncarcinogens.)

Chemical intake is used to estimate health risk, which is representative of the potential for adverse health effects. Health risk is estimated as either a noncarcinogenic HI or carcinogenic excess lifetime cancer risk (EPA 1989). The EPA chemical-specific toxicity dose-response values convert intake to health risk using equations explained further in the risk characterization section of this appendix (Section E.6.1.3).

E.5.5 Radiological Exposure Doses

Radiological doses to the maximally exposed member of the public and to the general population are calculated by the *Clean Air Assessment Package* (*CAP88-PC*) model from the radionuclide air emissions (see Appendix D, Section D.2). Dose is converted to individual MEI and population cancer risks using the appropriate health risk estimators for excess LCF and for excess nonfatal cancers and genetic disorders, as discussed in the risk characterization section of this appendix (Section E.6.1.3).

E.6 RISK CHARACTERIZATION

E.6.1 Analytical Methods Summary

Other resource area consequence analysis results provide input to the human health risk assessment. The "annual average" air concentrations of specific chemicals at specific receptor locations are modeled using *ISCST3* (EPA 1995a) (see Appendix D, Section D.1). The *Multimedia Environmental Pollutant Assessment System* (*MEPAS*) was used in the hydrology analysis to model the concentration of contaminants in groundwater at specific drinking water wells and springs (PNL 1995) (see Appendix B). General population doses due to transportation of radiological materials were modeled using *RADTRAN* (see Appendix G). Radiological doses from air emissions were modeled using *CAP88-PC* (DOE 1997e) (see Appendix D, Section D.2). Only those modeling results showing an environmental impact were used to further evaluate potential human exposures and risks to human health.

E.6.1.1 Worker Safety

Impacts were measured for both the involved and noninvolved worker populations at SNL/NM. Radiological impacts for the involved worker are evaluated using the dosimetry data available for the 1996 base year. These dosimetry data include the total collective individual and worker population doses, maximum individual worker dose, and number of radiation-badged workers. For the 1996 base year and for each alternative, SNL/NM has estimated total full-time equivalents (FTEs) (SNL/NM 1997b, 1998a). The number of radiation workers under each alternative is estimated by multiplying the total FTEs by the 1996 base-year ratio of radiation workers to total FTEs. Worker doses are estimated based on the radiation dose per radiation worker, multiplied by the total number of radiation workers.

The method used to estimate changes in the collective worker radiation dose is based on the change in number of radiation-badged workers under each alternative. This method is used because of the lack of workload adjustment factors available for a laboratory environment. In a research and development laboratory environment, workload is not as easily quantified as in a manufacturing environment. Therefore, estimates of the change in workforce size are used as a workload adjustment. This method assumes that the annual average dose to the radiation-badged worker and the ratio (number of radiation-badged workers/total number of SNL/NM workers) remain consistent with 1996 data. It is realized, however, that the estimated changes in workforce in radiation facilities may not occur as predicted by the alternatives (due to changes in operational efficiencies). However, it is expected that deviations from the current annual average radiation-badged worker dose and the relative number of radiation-badged workers will balance, and predictions of collective dose and subsequent health risk will not be affected.

Nonradiological impacts to the involved worker were evaluated using the illness/injury data available from 1992 through 1996 (SNL/NM 1997b, 1998a). Physical injury and illness rates (5-year average), derived from historic data (1992 through 1996), were used as multiplying factors to estimate the number of physical injuries and illnesses for each alternative based on the number of workers for each alternative.

Potential air pathway exposures to the noninvolved worker were modeled at the center of TA-I for chemicals and at the KUMMSC for radiation. Routine chemical air releases at SNL/NM were modeled using *ISCST3* to predict potential exposures to receptors located onsite in the center of TA-I, as representative of potential maximum exposures to the noninvolved worker. Air quality at this receptor location was compared to applicable occupational limits, such as the occupational exposure limits (OELs) for chemicals or the radiological dose limits of 5 rem/year to the worker and 100 mrem/year to a member of the public. Health impacts for noninvolved workers were calculated as they were for all other receptor locations.

E.6.1.2 Risk Characterization of Chemical Exposure

Risk characterization is the step in the risk assessment process that combines the results of the exposure assessment and the dose-response assessment for each COC to estimate the potential for carcinogenic and noncarcinogenic human health risks from chronic exposure to that COC. This section summarizes the results of the risk characterization for each of the receptor locations and the hypothetical worst-case residential exposure scenario evaluated in the chemical aspect of this risk assessment.

The risks for carcinogenic and noncarcinogenic COCs are characterized in different ways. Risks from chemicals with possible carcinogenic action are derived from the conservative assumption that a no-threshold mechanism exists, whereas risks from chemicals with possible other toxic actions may have a threshold (a dose below which few individuals would be affected). Because of these different approaches, it has become common to refer to COCs as carcinogens and noncarcinogens. Thus, under the no-threshold assumption, it is possible to simply characterize an exposure as above or below a specified RfD. A chemical can be both toxic and a carcinogen. In that case, both assessments are performed for that COC.

The potential for exposure to COCs to result in adverse noncarcinogenic health effects is estimated for each receptor by comparing the CDI for each COC (derived in Section E.5.4) with the RfD for that COC (presented in Section E.4). The resultant ratio, which is unitless, is known as the Hazard Quotient (HQ) for that COC. The HQ is calculated using the following formula:

$$\boxed{HQ = (CDI)/(RfD)}$$

(Eq. E.6–1)

Where: RfD = Reference Dose
CDI = Chronic Daily Intake
HQ = Hazard Quotient

Chemical-specific hazard quotient values for multiple noncarcinogenic chemicals are summed to get a total HI (see formula below).

$$\boxed{\text{Total HI} = \Sigma^{i}_{n} HQ_{i}}$$

(Eq. E.6–2)

Where: i = chemical "i"
n = total number of chemicals
$\Sigma^{i}_{n} = HQ_1 + HQ_2 + HQ_3 \ldots HQ_n$

A total HI of less than 1 indicates that no adverse noncarcinogenic health effects are expected to occur as a result of that receptor's potential chronic exposure to the COCs at SNL/NM, even if all COCs assessed are additive in their toxicity. An HI greater than 1 indicates the need to revisit the data to determine which of the COCs are truly additive in their toxicity. This is accomplished by assuming additivity only among chemicals with similar toxic mechanisms or toxic endpoints. An HI less than 1 for probable additive substances again indicates it is unlikely that an adverse additive effect will occur. HIs above 1 do not necessarily signify an effect will occur, but do suggest that the possibility exists. This possibility does not increase linearly with values greater than 1.

The purpose of carcinogenic risk characterization is to estimate the likelihood, over and above the background cancer rate, that a receptor will develop cancer in his or her lifetime as a result of chronic exposures to COCs released to the air from SNL/NM. This likelihood is a function of the dose of a COC (LADD) (derived in Section E.5.4) and the CSF (presented in Section E.4) for that COC.

The relationship between the ELCR and the estimated LADD of a COC may be expressed as [$ELCR = e^{-(CSFxLADD)}$]. When the product of the CSF and the LADD is much greater than 1, the ELCR approaches 1 (100 percent probability); however, when the product is less than 0.01 (1 chance in 100) the equation can be closely approximated by multiplying the LADD by the CSF to determine the ELCR to the individual as shown in the following formula:

$$\boxed{ELCR = (CSF)\ (LADD)}$$

(Eq. E.6–3)

Where: LADD = Lifetime Average Daily Dose
CSF = Cancer Slope Factor
ELCR = Excess Lifetime Cancer Risk (increased lifetime risk) from chemicals

Chemical-specific ELCR values for carcinogenic chemicals are also summed to determine the Total ELCR of all chemicals combined from all pathways, as shown below.

$$\boxed{\text{Total ELCR} = \Sigma^{i}_{n}ELCR_{I}}$$

(Eq. E.6–4)

Where: $\Sigma^{i}_{n} = ELCR_1 + ELCR_2 + ELCR_3 + \ldots ELCR_n$

The product of the CSF and the LADD is unitless and provides an upper-bound estimate of the potential lifetime carcinogenic risk associated with a receptor's exposure to the COC by way of the inhalation pathway. ELCRs are calculated for each potentially carcinogenic COC. A total ELCR of less $1x10^{-6}$ (one extra chance in one million) for a given receptor is considered to be below the EPA's target risk range. The EPA's target risk range for individual cancer risks is $1x10^{-4}$ to $1x10^{-6}$ that an exposed individual would develop an excess cancer in a lifetime (EPA 1989, 40 CFR Part 300).

Risks from chemicals are presented separately for each receptor location, the hypothetical worst-case scenarios, and the Lurance Canyon Burn Site (Four Hills Subdivision receptor location) (Section E.6.3).

E.6.1.3 Risk Characterization of Radiation Exposure

Radiation exposure and its consequences are of concern to the general public. Radiation can cause a variety of ill-health effects in people. The most significant ill-health effect is the induction of cancer fatalities due to radiation exposure. This effect is referred to as "latent" cancer fatalities because the cancer and subsequent death may take many years to develop. In addition, radiation exposure may also cause nonfatal cancers and genetic disorders.

The National Research Council's committee on the Biological Effects of Ionizing Radiation (BEIR) has prepared several reports to advise the government on the health consequences of radiation exposure. BEIR V provided health risk estimators that have been adopted by the National Council on Radiological Protection and Measurements (NCRP) (BEIR V 1990). These risk estimators are 500 excess latent fatal cancers per million person-rem for the general public and 400 excess latent fatal cancers per million person-rem for workers. The higher risk estimator for the general public reflects the inclusion of sensitive population groups, such as children. Based on recommendations of the International Commission on Radiological Protection (ICRP 1991), the health risk estimators for nonfatal cancer and genetic disorders among the general public are 20 percent (100 per million person-rem) and 26 percent (130 per million person-rem), respectively, of the fatal cancer risk estimator of 500 latent fatal cancers per million person-rem. For workers, they are both 20 percent (80 per million person-rem) of the fatal cancer risk estimator of 400 latent fatal cancers per million person-rem.

The risk of fatal cancer to the MEI is determined by multiplying the risk estimator of 500 per million person-rem with the calculated total MEI dose (rem) from all pathways.

$$\text{Risk of fatal cancer from annual exposure} = \left(\frac{500}{10^{6}\,\text{person} - \text{rem}}\right) \times \begin{pmatrix}\text{total}\\ \text{MEI}\\ \text{annual}\\ \text{dose}\\ (\text{mrem})\end{pmatrix} \frac{1\text{rem}}{1{,}000\text{mrem}}$$

(Eq. E.6–5)

Similarly, the risk of a fatal cancer to a worker is determined by multiplying the risk estimator of 400 per million person-rem with the calculated total individual worker dose (rem). The number of LCFs in the general population or in the workforce is determined by multiplying 500 latent fatal cancers per million person-rem with the calculated collective population dose (person-rem), or 400 latent fatal cancers per million person-rem with the calculated collective workforce dose (person-rem), respectively.

$$\text{Total number of fatal cancers in general population from annual exposure} = \left(\frac{500}{10^6\ \text{person}-\text{rem}}\right) \times \left(\begin{array}{c}\text{annual}\\ \text{collective}\\ \text{dose(person}-\text{rem)}\end{array}\right)$$

or

$$\text{Total number of fatal cancers in worker population from annual exposure} = \left(\frac{400}{10^6\ \text{person}-\text{rem}}\right) \times \left(\begin{array}{c}\text{annual}\\ \text{wor ker}\\ \text{population}\\ \text{collective}\\ \text{dose}\\ \text{(person}-\text{rem)}\end{array}\right)$$

(Eq. E.6–6)

Using the same calculated doses, the nonfatal cancer and genetic disorders are calculated by multiplying the dose to the public by 100 nonfatal cancers and 130 genetic effects per million person-rem, respectively, and by multiplying the dose to workers by 80 nonfatal and 80 genetic effects per million person-rem, respectively. The summary of doses and corresponding health impacts (to the MEI and population) per year of operation are presented in Table E.6–1. A summary of doses and corresponding risk of fatal cancers for individuals at specific receptor locations is presented in Table E.6–2.

E.6.1.4 Composite Cancer Risk

The calculated lifetime excess cancer risks are further considered in deriving a "composite" cancer risk at specific receptor locations where exposure to both carcinogenic chemicals and radiological components may occur simultaneously. Because genetic disorders are only calculated for radiological exposures, a composite human health risk is not appropriate. Therefore, these effects are presented independently.

The composite cancer risk for an individual member of the public, due to both chemical and radiological exposures at the same location, is derived two ways. First, to capture the maximum potential radiation dose, the MEI radiological annual increased lifetime cancer risk was converted to a long-term exposure by multiplying by 30 years. This is consistent with the exposure duration used for assessing the adult/child integrated chemical exposures (Section E.5.5). Then, the MEI radiological fatal (lifetime) cancer risk was added to the ELCR due to chemical exposure at that location (KUMMSC).

In other words, the ELCR from chemicals is summed with excess LCF risk from radiation after the radiological LCF risk is presented as a long-term exposure (annual LCF x 30-year duration) using the following equation:

$$\boxed{\text{Composite cancer risk} = (\text{Total ELCR}) + (\text{MEI LCF x 30 yr})}$$

(Eq. E6–7)

Where: ELCR = Excess Lifetime Cancer Risk from Chemicals
MEI LCF = Increased Lifetime Risk of Latent Cancer Fatality to the Radiological MEI from a 1-year dose

Second, to capture the potential maximum chemical exposure, composite cancer risk was derived by adding the upper-bound (hypothetical worst-case exposure scenario) chemical ELCR to the MEI radiological cancer risk. This was an implausible scenario because these exposures would not occur at the same location. A conservative assessment captured the upper-bound chemical risk and upper-bound composite risk.

For the possible additive effects of exposures to radiation by way of the air pathway and the transportation of radiological materials within the ROI, the risk of LCF to the population along the transportation route within the ROI due to the routine transportation of radiological materials was summed with the LCF to the total population within the ROI from routine air releases of radionuclides. Ten percent of the annual collective population dose (off-link and on-link) from all transportation activities was used to derive the LCFs from transportation activities within the 50-mi ROI population (see Appendix G). Ten percent of the risk from transportation was summed with the ROI population LCFs from routine air emissions to get a total number of LCFs applicable to those in the ROI along the transportation route (see Sections 5.3.8, 5.4.8, and 5.5.8).

Overall, the total risks of cancer due to SNL/NM operations can be put in perspective. The U.S. national cancer rate is that between 20 percent and 25 percent of the population will develop cancer in their lifetime (ACS 1997).

Table E.6–1. Summary of Calculated Annual Radiation Doses and Health Effects per Year of the Operation to the MEI and General Population

ALTERNATIVE	MEI (KUMMSC)				POPULATION			
	DOSE (mrem/yr)	RISK OF FATAL CANCER	RISK OF NONFATAL CANCER	RISK OF GENETIC DISORDERS	COLLECTIVE DOSE (person-rem)	TOTAL FATAL CANCERS	TOTAL NONFATAL CANCERS	TOTAL GENETIC DISORDERS
No Action	0.15	7.5×10^{-8}	1.5×10^{-8}	2.0×10^{-8}	5.0 (0.55)[a]	2.5×10^{-3}	5.0×10^{-4}	6.5×10^{-4}
Expanded Operations[b]	0.51	2.6×10^{-7}	5.1×10^{-8}	6.6×10^{-8}	15.8 (1.62)[a]	7.9×10^{-3}	1.6×10^{-3}	2.1×10^{-3}
Reduced Operations	0.016	8.0×10^{-9}	1.6×10^{-9}	2.1×10^{-9}	0.80 (0.101)[a]	4.0×10^{-4}	8.0×10^{-5}	1.0×10^{-4}

Source: DOE 1997e
MEI: maximally exposed individual
KUMMSC: Kirtland Underground Munitions and Maintenance Storage Complex
mrem/year: millirem per year
rem: Roentgen equivalent, man
[a] Portion of dose due to ingestion of crops and livestock
[b] If implemented, the Microsystems and Engineering Sciences Applications (MESA) Complex configuration would not change the annual radiation doses and health effects under the Expanded Operation Alternative.
Note: Calculated by *CAP88-PC*

Table E.6–2. Summary of Radiation Doses and Health Effects at Specific Receptor Locations Under Each Alternative

RECEPTOR LOCATION	NO ACTION		EXPANDED OPERATIONS[a]		REDUCED OPERATIONS	
	DOSE (mrem/yr)	RISK OF CANCER FATALITY	DOSE (mrem/yr)	RISK OF CANCER FATALITY	DOSE (mrem/yr)	RISK OF CANCER FATALITY
Child Development Center-East	$1.8x10^{-2}$	$9.0x10^{-9}$	$5.4x10^{-2}$	$2.7x10^{-8}$	$5.1x10^{-3}$	$2.6x10^{-9}$
Child Development Center-West	$1.9x10^{-2}$	$9.5x10^{-9}$	$6.2x10^{-2}$	$3.1x10^{-8}$	$2.6x10^{-3}$	$1.3x10^{-9}$
Coronado Club	$2.0x10^{-2}$	$1.0x10^{-8}$	$5.5x10^{-2}$	$2.8x10^{-8}$	$5.7x10^{-3}$	$2.9x10^{-9}$
Four Hills Subdivision	$4.1x\ 10^{-2}$	$2.1x10^{-8}$	$1.1x10^{-1}$	$5.5x10^{-8}$	$1.0x10^{-2}$	$5.0x10^{-9}$
Golf Course (clubhouse)	$7.2x10^{-2}$	$3.6x10^{-8}$	$2.3x10^{-1}$	$1.2x10^{-7}$	$7.9x10^{-3}$	$4.0x10^{-9}$
Kirtland Elementary School	$1.9x10^{-2}$	$9.5x10^{-9}$	$6.1x10^{-2}$	$3.1x10^{-8}$	$2.5x10^{-3}$	$1.3x10^{-9}$
KAFB Housing (Zia Park Housing)	$2.4x10^{-2}$	$1.2x10^{-8}$	$6.6x10^{-2}$	$3.3x10^{-8}$	$5.8x10^{-3}$	$2.9x10^{-9}$
Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC)	$1.5x10^{-1}$	$7.5x10^{-8}$	$5.1x10^{-1}$	$2.6x10^{-7}$	$1.6x10^{-2}$	$8.0x10^{-9}$
Lovelace Hospital	$1.4x10^{-2}$	$7.0x10^{-9}$	$4.5x10^{-2}$	$2.3x10^{-8}$	$2.8x10^{-3}$	$1.4x10^{-9}$
National Atomic Museum	$2.5x10^{-2}$	$1.3x10^{-8}$	$6.9x10^{-2}$	$3.5x10^{-8}$	$9.0x10^{-3}$	$4.5x10^{-9}$
Riding Stables	$6.3x10^{-2}$	$3.2x10^{-8}$	$2.1x10^{-1}$	$1.1x10^{-7}$	$6.8x10^{-3}$	$3.4x10^{-9}$
Sandia Base Elementary School	$1.7x10^{-2}$	$8.5x10^{-9}$	$4.3x10^{-2}$	$2.2x10^{-8}$	$4.1x10^{-3}$	$2.1x10^{-9}$
Shandiin Day Care Center	$2.2x10^{-2}$	$1.1x10^{-8}$	$6.3x10^{-2}$	$3.2x10^{-8}$	$6.3x10^{-3}$	$3.2x10^{-9}$
Isleta Gaming Palace	$2.7x10^{-2}$	$1.4x10^{-8}$	$6.6x10^{-2}$	$3.3x10^{-8}$	$1.1x10^{-2}$	$5.5x10^{-9}$
Veterans Affairs Medical Center	$2.7x10^{-2}$	$1.4x10^{-8}$	$8.4x10^{-2}$	$4.2x10^{-8}$	$4.0x10^{-3}$	$2.0x10^{-9}$
Wherry Elementary School	$1.8x10^{-2}$	$9.0x10^{-9}$	$5.2x10^{-2}$	$2.6x10^{-8}$	$4.5x10^{-3}$	$2.3x10^{-9}$

Source: DOE 1997e
mrem/yr: millirems per year
KAFB: Kirtland Air Force Base
[a] If implemented, the Microsystems and Engineering Sciences Applications (MESA) Complex configuration would not change the annual radiation doses and health effects at specific receptor locations under the Expanded Operations Alternative.
Note: Calculation made using *CAP88-PC*

E.6.2 Assumptions

The following facts and assumptions were integrated into the human health and worker safety impacts assessment:

- Human health impacts from accidents were expressed as impacts per accident, not as impacts per year. Therefore, they were not added to the human health impacts from routine operations. Impacts from accidents are presented independently.
- Modeling for carcinogenic hazardous air pollutant emissions addressed the same receptor locations addressed for radiological air emissions, as well as other receptor locations specific to chemical emissions, to allow for the composite risk assessment.
- Drinking contaminated groundwater was not a completed exposure pathway.
- The reference-person used to evaluate risk to human health was the standard adult/child receptor, based on the available toxicity criteria that have conservative uncertainty factors integrated into them in order to protect of a wide range of human receptors.
- Workers' doses from transportation activities involving radioactive materials were collectively covered in historic dosimetry data. A separate estimate of transportation worker doses was not presented.
- Drinking surface water was not a completed exposure pathway.
- The soil pathway (inhalation, ingestion) was not a completed exposure pathway for nonradiological contaminants. Estimates of radiological impacts by way of soils were modeled by *CAP88-PC* (DOE 1997e).
- The total collective population radiation dose calculated by *CAP88-PC* for radiation exposures took into account all environmental pathways directly and indirectly associated with air emissions (such as ingestion of locally grown crops and livestock).

E.6.3 Risk Results

Tables E.6–3 through E.6–8 present risk results to human health from chemical air emissions and radiological air emissions under each of the three alternatives. The Expanded Operations Alternative, Table E.6–4 and E.6–7, includes risk results to human health for the MESA Complex configuration, if implemented.

E.6.4 Uncertainty

Within the risk assessment process, assumptions must be made due to a lack of absolute scientific knowledge. Some of the assumptions are supported by considerable scientific evidence, while others have less scientific support. Every assumption introduces some degree of uncertainty into the risk assessment process. Conservative assumptions are made throughout the risk assessment to ensure the protection of public health. Therefore, when all of the assumptions are added together, it is much more likely that risks are overestimated rather than underestimated (EPA 1989).

The assumptions that introduce the greatest amount of uncertainty in the risk assessment are discussed in this section. They are discussed in general terms because, for most of the assumptions, there is not enough information to assign them a numerical value that can be factored in the calculation of risk estimates.

E.6.4.1 Uncertainties of Data Evaluation and Selection of Chemicals of Potential Concern

Information on both fugitive and stack emissions chemicals is combined with measures of their potential toxicities to obtain a subset of chemical constituents for evaluation in the risk assessment. Uncertainty is introduced in two principal areas during this step: emission estimates and selection of the COCs. Overall, the data evaluation process overestimates site risks.

The data used to develop the risk assessment were estimated emissions from various facility sources at SNL/NM and from the Lurance Canyon Burn Site. Uncertainties associated with emission estimation or in data collection may lead to over or underestimation of corresponding risk estimates. The emission estimation was modeled by *ISCST3* (EPA 1995a) using conservative parameters and assumptions (Appendix D). The emission estimates from the Lurance Canyon Burn Site assume that a resident would be located at the nearest eastern site boundary (closer than the actual distance to the Four Hills Subdivision) and that burn activities take place up to 58 times per year (Expanded Operations Alternative with or without MESA). Therefore, due to the conservative nature of the data evaluated in the risk assessment, the overall effect on the risk assessment is an overestimation of risk.

In the selection of COCs, the individual building quantities of hazardous air pollutants, toxic air pollutants, and volatile organic compounds were screened using a threshold emission value (TEV) calculated from the

Table E.6–3. Human Health Impacts in the Vicinity of SNL/NM from Chemical Air Emissions Under the No Action Alternative

RECEPTOR LOCATIONS	RECEPTOR	TOTAL HAZARD INDEX RME/AEI	TOTAL EXCESS LIFETIME CANCER RISK RME/AEI
RESIDENTIAL SCENARIOS			
Upper-Bound Value[a]	Adult	0.01/<0.01	$1.4x10^{-7}/5.8x10^{-9}$
	Child	0.02/<0.01	$5.3x10^{-8}/5.1x10^{-9}$
Four Hills Subdivision[b]	Adult	<0.01/<0.01	$3.7x10^{-11}/2.3x10^{-11}$
	Child	<0.01/<0.01	$1.5x10^{-11}/1.5x10^{-11}$
Isleta Gaming Palace	Adult	<0.01/<0.01	$1.6x10^{-9}/1.7x10^{-11}$
	Child	<0.01/<0.01	$1.1x10^{-9}/1.3x10^{-11}$
KAFB Housing (Zia Park Housing)	Adult	<0.01/<0.01	$6.7x10^{-10}/7.0x10^{-12}$
	Child	<0.01/<0.01	$4.7x10^{-10}/5.3x10^{-12}$
WORKER SCENARIOS			
Center of TA-I[c]	Adult	<0.01/<0.01	$8.9x10^{-8}/6.9x10^{-10}$
Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC)	Adult	<0.01/<0.01	$3.8x10^{-10}/4.0x10^{-12}$
VISITOR SCENARIOS			
Child Development Center-East	Child	<0.01/<0.01	$6.1x10^{-10}/6.9x10^{-12}$
Child Development Center-West	Child	<0.01/<0.01	$1.2x10^{-10}/1.4x10^{-12}$
Coronado Club	Adult	<0.01/<0.01	$1.1x10^{-9}/1.1x10^{-11}$
	Child	<0.01/<0.01	$7.4x10^{-10}/8.4x10^{-12}$
Golf Course (clubhouse)	Adult	<0.01/<0.01	$3.8x10^{-10}/3.9x10^{-12}$
Kirtland Elementary School	Child	<0.01/<0.01	$1.0x10^{-10}/1.1x10^{-12}$
Lovelace Hospital	Adult	<0.01/<0.01	$3.0x10^{-10}/3.1x10^{-12}$
	Child	<0.01/<0.01	$2.1x10^{-10}/2.3x10^{-12}$
National Atomic Museum	Adult	<0.01/<0.01	$1.8x10^{-9}/1.9x10^{-11}$
	Child	<0.01/<0.01	$1.3x10^{-9}/1.4x10^{-11}$
Riding Stables	Adult	<0.01/<0.01	$3.0x10^{-10}/3.0x10^{-12}$
Sandia Base Elementary School	Child	<0.01/<0.01	$8.2x10^{-10}/9.3x10^{-12}$
Shandiin Day Care Center	Child	<0.01/<0.01	$6.9x10^{-10}/7.8x10^{-12}$
Veterans Affairs Medical Center	Adult	<0.01/<0.01	$2.9x10^{-10}/3.0x10^{-12}$
Wherry Elementary School	Child	<0.01/<0.01	$4.6x10^{-10}/5.2x10^{-12}$

Source: SmartRISK 1996
RME: Reasonable Maximum Exposure
AEI: Average Exposed Individual
TA: technical area
KAFB: Kirtland Air Force Base
[a] Upper-bound risk values based on SNL/NM building air emissions.
[b] Four Hills Subdivision receptor location impacts are based on Lurance Canyon Burn Site open burning air emissions, not SNL/NM building air emissions.
[c] Receptor location selected for proximity to chemical air emission sources.

Table E.6–4. Human Health Impacts in the Vicinity of SNL/NM from Chemical Air Emissions Under the Expanded Operations Alternative

RECEPTOR LOCATIONS	RECEPTOR	TOTAL HAZARD INDEX RME/AEI	TOTAL EXCESS LIFETIME CANCER RISK RME/AEI (WITH MESA)
RESIDENTIAL SCENARIOS			
Upper-Bound Value[a]	Adult	0.01/<0.01	$1.4\times10^{-7}/5.8\times10^{-9}$ ($1.1\times10^{-7}/4.3\times10^{-9}$)
	Child	0.02/<0.01	$5.3\times10^{-8}/5.0\times10^{*9}$ ($3.9\times10^{-8}/3.7\times10^{-9}$)
Four Hills Subdivision[b]	Adult	<0.01/<0.01	$2.1\times10^{-10}/1.3\times10^{*-11}$ ($2.1\times10^{-10}/1.3\times10^{*-11}$)
	Child	<0.01/<0.01	$8.5\times10^{*-10}/8.5\times10^{-11}$ ($8.5\times10^{*-10}/8.5\times10^{-11}$)
Isleta Gaming Palace	Adult	<0.01/<0.01	$1.7\times10^{-9}/1.7\times10^{-11}$ ($4.3\times10^{-10}/4.4\times10^{-12}$)
	Child	<0.01/<0.01	$1.2\times10^{-9}/1.3\times10^{-11}$ ($3.0\times10^{-10}/3.4\times10^{-12}$)
KAFB Housing (Zia Park Housing)	Adult	<0.01/<0.01	$7.8\times10^{-10}/8.0\times10^{-12}$ ($7.2\times10^{-10}/7.4\times10^{-12}$)
	Child	<0.01/<0.01	$5.4\times10^{-10}/6.1\times10^{-12}$ ($5.0\times10^{-10}/5.7\times10^{-12}$)
WORKER SCENARIOS			
Center of TA-I[c]	Adult	<0.01/<0.01	$9.4\times10^{-8}/7.3\times10^{-10}$ ($7.9\times10^{-8}/6.1\times10^{-10}$)
Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC)	Adult	<0.01/<0.01	$4.5\times10^{-10}/4.7\times10^{-12}$ ($3.3\times10^{-10}/3.4\times10^{-12}$)
VISITOR SCENARIOS			
Child Development Center-East	Child	<0.01/<0.01	$7.2\times10^{-10}/8.1\times10^{-12}$ ($5.0\times10^{*10}/5.6\times10^{-12}$)
Child Development Center-West	Child	<0.01/<0.01	$1.5\times10^{-10}/1.7\times10^{-12}$ ($1.1\times10^{-10}/1.3\times10^{-12}$)
Coronado Club	Adult	<0.01/<0.01	$1.2\times10^{-9*}/1.3\times10^{-11}$ ($8.8\times10^{-10}/9.0\times10^{-12}$)
	Child	<0.01/<0.01	$8.7\times10^{-10}/9.8\times10^{-12}$ ($6.1\times10^{-10}/6.9\times10^{-12}$)
Golf Course (clubhouse)	Adult	<0.01/<0.01	$4.4\times10^{-10}/4.5\times10^{-12}$ $4.8\times10^{-10}/4.9\times10^{-12}$
Kirtland Elementary School	Child	<0.01/<0.01	$4.0\times10^{-11}/4.5\times10^{-13}$ ($3.5\times10^{-11}/3.9\times10^{-13}$)
Lovelace Hospital	Adult	<0.01/<0.01	$3.5\times10^{-10}/3.6\times10^{-12}$ ($2.5\times10^{-10}/2.6\times10^{*12}$)
	Child	<0.01/<0.01	$2.5\times10^{-10}/2.8\times10^{-12}$ ($1.8\times10^{-10}/2.0\times10^{-12}$)

Table E.6–4. Human Health Impacts in the Vicinity of SNL/NM from Chemical Air Emissions Under the Expanded Operations Alternative (concluded)

RECEPTOR LOCATIONS	RECEPTOR	TOTAL HAZARD INDEX RME/AEI	TOTAL EXCESS LIFETIME CANCER RISK RME/AEI (WITH MESA)
National Atomic Museum	Adult	<0.01/<0.01	$2.1x10^{-9}/2.1x10^{-11}$ ($1.7x10^{-9}/1.8x10^{-11}$)
	Child	<0.01/<0.01	$1.4x10^{-9}/1.6x10^{-11}$ ($1.2x10^{-9}/1.4x10^{-11}$)
Riding Stables	Adult	<0.01/<0.01	$3.0x10^{-10}/3.1x10^{-12}$ ($2.8x10^{-10}/2.9x10^{-12}$)
Sandia Base Elementary School	Child	<0.01/<0.01	$9.7x10^{-10}/1.1x10^{-11}$ ($5.8x10^{-10}/6.5x10^{-12}$)
Shandiin Day Care Center	Child	<0.01/<0.01	$7.9x10^{-10}/9.0x10^{-12}$ ($7.1x10^{-10}/8.0x10^{-12}$)
Veterans Affairs Medical Center	Adult	<0.01/<0.01	$3.4x10^{-10}/3.5x10^{-12}$ ($3.0x10^{-10}/3.1x10^{-12}$)
Wherry Elementary School	Child	<0.01/<0.01	$5.4x10^{-10}/6.1x10^{-12}$ ($3.7x10^{-10}/4.2x10^{-12}$)

Source: SmartRISK 1996
RME: Reasonable Maximum Exposure
AEI: Average Exposed Individual
TA: technical area
KAFB: Kirtland Air Force Base
MESA: Microsystems and Engineering Sciences Applications

[a] Upper-bound risk values based on SNL/NM building air emissions.
[b] Four Hills Subdivision receptor location impacts are based on Lurance Canyon Burn Site open burning air emissions, not SNL/NM building air emissions, therefore, no change due to MESA Complex.
[c] Receptor location selected for proximity to chemical air emissions sources.

Table E.6–5. Human Health Impacts in the Vicinity of SNL/NM from Chemical Air Emissions Under the Reduced Operations Alternative

RECEPTOR LOCATIONS	RECEPTOR	TOTAL HAZARD INDEX RME/AEI	TOTAL EXCESS LIFETIME CANCER RISK RME/AEI
RESIDENTIAL SCENARIOS			
Upper-Bound Value [a]	Adult	<0.01/<0.01	$9.5x10^{-8}/3.8x10^{-9}$
	Child	<0.01/<0.01	$3.5x10^{-8}/3.3x10^{-9}$
Four Hills Subdivision	Adult	<0.01/<0.01	$1.8x10^{-11}/1.1x10^{-11}$
	Child	<0.01/<0.01	$7.4x10^{-12}/7.4x10^{-12}$
Isleta Gaming Palace	Adult	<0.01/<0.01	$1.7x10^{-10}/1.7x10^{-12}$
	Child	<0.01/<0.01	$1.2x10^{-10}/1.3x10^{-12}$
KAFB Housing (Zia Park Housing)	Adult	<0.01/<0.01	$3.6x10^{-10}/3.8x10^{-12}$
	Child	<0.01/<0.01	$2.5x10^{-10}/2.9x10^{-12}$
WORKER SCENARIOS			
Center of TA-I	Adult	<0.01/<0.01	$5.7x10^{-8}/4.4x10^{-10}$
Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC)	Adult	<0.01/<0.01	$1.8x10^{-10}/1.8x10^{-12}$
VISITOR SCENARIOS			
Child Development Center-East	Child	<0.01/<0.01	$3.4x10^{-10}/3.9x10^{-12}$
Child Development Center-West	Child	<0.01/<0.01	$6.7x10^{-11}/7.6x10^{-13}$
Coronado Club	Adult	<0.01/<0.01	$5.9x10^{-10}/6.0x10^{-12}$
	Child	<0.01/<0.01	$4.1x10^{-10}/4.6x10^{-12}$
Golf Course (clubhouse)	Adult	<0.01/<0.01	$1.9x10^{-10}/1.9x10^{-12}$
Kirtland Elementary School	Child	<0.01/<0.01	$5.5x10^{-11}/6.2x10^{-13}$
Lovelace Hospital	Adult	<0.01/<0.01	$1.6x10^{-10}/1.7x10^{-12}$
	Child	<0.01/<0.01	$1.1x10^{-10}/1.3x10^{-12}$
National Atomic Museum	Adult	<0.01/<0.01	$9.9x10^{-10}/1.0x10^{-11}$
	Child	<0.01/<0.01	$6.9x10^{-10}/7.8x10^{-12}$
Riding Stables	Adult	<0.01/<0.01	$9.7x10^{-11}/1.0x10^{-12}$
Sandia Base Elementary School	Child	<0.01/<0.01	$4.7x10^{-10}/5.3x10^{-12}$
Shandiin Day Care Center	Child	<0.01/<0.01	$3.7x10^{-10}/4.2x10^{-12}$
Veterans Affairs Medical Center	Adult	<0.01/<0.01	$1.6x10^{-10}/1.6x10^{-12}$
Wherry Elementary School	Child	<0.01/<0.01	$2.5x10^{-10}/2.8x10^{-12}$

Source: SmartRISK 1996
RME: Reasonable Maximum Exposure
AEI: Average Exposed Individual
TA: technical area
KAFB: Kirtland Air Force Base

[a] Upper-bound risk values based on SNL/NM building air emissions.
[b] Four Hills Subdivision receptor location impacts are based on Lurance Canyon Burn Site open burning air emissions, not SNL/NM building air emissions.
[c] Receptor location selected for proximity to chemical air emission sources.

Table E.6–6. Human Health Impacts in the Vicinity of SNL/NM from Radiological Air Emissions Under the No Action Alternative

RECEPTOR LOCATIONS	LIFETIME RISK OF FATAL CANCER FROM A 1-YEAR DOSE
Child Development Center-East	9.0×10^{-9}
Child Development Center-West	9.5×10^{-9}
Coronado Club	1.0×10^{-8}
Four Hills Subdivision	2.1×10^{-8}
Golf Course	3.6×10^{-8}
Kirtland Elementary School	9.5×10^{-9}
KAFB Housing (Zia Park Housing)	1.2×10^{-8}
Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC)	7.5×10^{-8}
Lovelace Hospital	7.0×10^{-9}
National Atomic Museum	1.3×10^{-8}
Riding Stables	3.2×10^{-8}
Sandia Base Elementary School	8.5×10^{-9}
Shandiin Day Care Center	1.1×10^{-8}
Isleta Gaming Palace	1.4×10^{-8}
Veterans Affairs Medical Center	1.4×10^{-8}
Wherry Elementary School	9.0×10^{-9}

Source: DOE 1997e
KAFB: Kirtland Air Force Base
Note: Calculations made by *CAP88-PC*

Table E.6–7. Human Health Impacts in the Vicinity of SNL/NM from Radiological Air Emissions Under the Expanded Operations Alternative[a]

RECEPTOR LOCATIONS	LIFETIME RISK OF FATAL CANCER FROM A 1-YEAR DOSE
Child Development Center-East	2.7×10^{-8}
Child Development Center-West	3.1×10^{-8}
Coronado Club	2.8×10^{-8}
Four Hills Subdivision	5.5×10^{-8}
Golf Course	1.2×10^{-7}
Kirtland Elementary School	3.1×10^{-8}
KAFB Housing (ZIA Park Housing)	3.3×10^{-8}
Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC)	2.6×10^{-7}
Lovelace Hospital	2.3×10^{-8}
National Atomic Museum	3.5×10^{-8}
Riding Stables	1.1×10^{-7}
Sandia Base Elementary School	2.2×10^{-8}
Shandiin Day Care Center	3.2×10^{-8}
Isleta Gaming Palace	3.3×10^{-8}
Veterans Affairs Medical Center	4.2×10^{-8}
Wherry Elementary School	2.6×10^{-8}

Source: DOE 1997e
KAFB: Kirtland Air Force Base
[a] If implemented, the Microsystems and Engineering Sciences Applications (MESA) Complex configuration would not change the radiological air emissions under the Expanded Operations Alternative.
Note: Calculations made by *CAP88-PC*

Table E.6–8. Human Health Impacts in the Vicinity of SNL/NM from Radiological Air Emissions Under the Reduced Operations Alternative

RECEPTOR LOCATION	LIFETIME RISK OF FATAL CANCER FROM A 1-YEAR DOSE
Child Development Center-East	2.6×10^{-9}
Child Development Center-West	1.3×10^{-9}
Coronado Club	2.9×10^{-9}
Four Hills Subdivision	5.0×10^{-9}
Golf Course	4.0×10^{-9}
Kirtland Elementary School	1.3×10^{-9}
KAFB Housing (ZIA Park Housing)	2.9×10^{-9}
Kirtland Underground Munitions and Maintenance Storage Complex (KUMMSC)	8.0×10^{-9}
Lovelace Hospital	1.4×10^{-9}
National Atomic Museum	4.5×10^{-9}
Riding Stables	3.4×10^{-9}
Sandia Base Elementary School	2.1×10^{-9}
Shandiin Day Care Center	3.2×10^{-9}
Isleta Gaming Palace	5.5×10^{-9}
Veterans Affairs Medical Center	2.0×10^{-9}
Wherry Elementary School	2.3×10^{-9}

Source: DOE 1997e
KAFB: Kirtland Air Force Base
Note: Calculations made by *CAP88-PC*

health guidelines (OEL unit risk factors) protective of human health. Estimates of chemical quantities released as routine air emissions and exceeding the TEVs were considered to be the COCs. If a chemical constituent did not have a published health guideline, the constituent could not be considered a COC. Some assumptions were made, such as, the chemical was controlled under Occupational Safety and Health Administration regulations at the facility; material safety data sheets were available for worker protection, as necessary; and chronic exposures offsite would not be anticipated. Furthermore, the requirement of establishing a health guideline is to handle potentially hazardous chemicals. If no health guideline exists, the assumption was made that the hazards may be low relative to the chemical's use. These assumptions for the selection of COCs may underestimate the contribution from the nonregulated pollutants to the overall risk estimates.

In addition, some potential COCs (those not screened out by the air quality analysis) did not have dose-response toxicity RfDs available. These chemicals could not be included in the calculation of either noncarcinogenic or carcinogenic health risks. However, these were qualitatively assessed for potential health effects, but were not associated with chronic health effects. Chromium trioxide and 1, 4-dioxane were identified as routine air emissions but toxicity information does not identify them as an inhalation health risk. Although these chemicals are toxic by ingestion, health risks for them through the air pathway were unidentifiable, and they were screened from the COC list. This type of uncertainty potentially may underestimate risk, but not in all cases.

E.6.4.2 Uncertainties in Dose-Response Assessment

Dose-response values are usually based on limited toxicological data. For this reason, a large margin of safety is built into estimates of both carcinogenic and noncarcinogenic risks. There are two major areas of uncertainty in the dose-response assessment: 1) animal to human extrapolation; and 2) high to low dose extrapolation (laboratory studies use high doses and actual environmental exposures occur at low doses). Two major contributors to uncertainty in the dose-response assessment are the necessity (usually) of extrapolating effects on humans from tests on laboratory animals and extrapolating effects observed at high doses to those likely at low doses. Further, data are often limited to one or a few studies. For these reasons, a large margin of safety is built into the factors used to estimate both cancer and noncancer risks, such as setting the human "safe" exposure level a thousand times lower than that actually measured for a laboratory animal. These safety factors make it much more likely that risks will be overestimated than underestimated. The large margin of safety in the dose-response values also accounts for the uncertainties that may be associated with chemical interaction. According to the EPA, the simplistic approach of assuming additive effects of chemicals is generally appropriate, unless potentially high risks exist (EPA 1989).

E.6.4.3 Uncertainties in Exposure Assessment

Exposure point concentrations were estimated and exposure doses were calculated. Exposure point concentrations are the estimated concentrations of chemicals to which humans outdoors may be exposed. A range of exposures at different locations was evaluated in the risk assessment. The RME assumptions were conservative and were likely to overestimate potential SNL/NM site risks. The AEI exposure assumptions were not likely to either overestimate or underestimate potential site risks.

E.6.4.4 Uncertainties in Risk Characterization

The risk of adverse human health effects depends on estimated levels of exposure and dose-response relationships. Two important additional sources of uncertainty are introduced in this phase of the risk assessment: 1) the evaluation of potential exposure to more than one chemical, and 2) the presence of subpopulations that may be particularly sensitive.

Once exposure to and risk from each of the selected chemicals was calculated, the total risk posed by the site was determined by combining the health risk contributed by each chemical. Threshold (noncarcinogenic) effects were added together, as represented by the total HI, unless there was evidence that the chemicals being studied act synergistically (result in a response that is greater than expected) or antagonistically (result in a response that is less than expected) with each other (Klaassen et al. 1986). The same practice was used for potential carcinogenic effects. According to the EPA's *Risk Assessment Guidance for Superfund Sites* (EPA 1989), when total cancer risks are less than 0.1, the simplistic approach of additive risks is appropriate. Additionally, because cancer slope factors are based on upper 95th values, and because upper 95th percentiles of probability distributions are not strictly additive, the total cancer risk estimates might become artificially more conservative as risks from a number of different carcinogens are summed (EPA 1989). For virtually all combinations of chemicals potentially released from the SNL/NM facility, there was little or no evidence of interaction. Therefore, it was assumed that carcinogenic effects may be added together. This uncertainty may cause an underestimation or overestimation of risk.

The health risks estimated in the risk characterization apply to the various locations where air concentrations are estimated or at locations where potential receptors are assumed to be located. Some people will always be more sensitive than the average person and, therefore, will be at greater risk. However, dose-response values used to calculate risk take into account potentially sensitive individuals. Therefore, it is unlikely that this source of uncertainty contributes significantly to the overall uncertainty of the risk assessment.

E.7 WORKER IMPACTS

E.7.1 Nonradiological Injury/Illness Rates

Health impacts from environmental releases of hazardous or radiological materials from SNL/NM operations are not the primary risk to workers. Routine operations at SNL/NM are conducted according to extensive worker health and safety requirements. These requirements control worker exposures to chemicals and radionuclides to the greatest extent possible. The more significant worker health impacts to assess are the risks from industrial accidents, injuries, and illnesses. Therefore, for the general SNL/NM worker population, physical injury and illness rates and radiological dose rates to the radiation workers were evaluated. The number of SNL/NM worker nonfatal occupational injuries/illnesses were calculated under each alternative.

The 5-year average nonfatal occupational injury/illness rate for 100 workers (or 200,000 hours) and the 5-year average SNL/NM worker population size were used to determine the number of SNL/NM worker nonfatal occupational injuries/illnesses per year for the entire SNL/NM workforce under each alternative. It was assumed the 5-year average rate would remain constant for all alternatives and, based on numbers of workers only, the total number of illnesses/injuries would vary. The SNL/NM worker nonfatal occupational injury/illness rates shown in Section 4.10 were used to calculate the 5-year average (1992-1996) SNL/NM nonfatal occupational injury/illness rate of 3.5. The annual 1992 to 1996 SNL/NM worker population values provided in the SNL/NM *Environmental Information Document* (SNL/NM 1997a) were used to calculate the 5-year SNL/NM worker population average of 8,463 (see Table E.7–1).

Conservative calculations were made in estimating the SNL/NM worker population for each alternative. A percentage factor was assigned for each alternative and was directly related to an increase or decrease in the number of SNL/NM workers for each alternative (see Sections 5.3.12, 5.4.12. and 5.5.12). The 5-year SNL/NM worker population average was multiplied by the percentage factor for each alternative to obtain the

Table E.7–1. SNL/NM Five-Year Average (1992-1996) Illness/Injury Rate

DATA ITEMS	YEAR 1992	1993	1994	1995	1996	5-year Average
Annual SNL/NM Worker Population Size	8,589	8,608	8,561	8,522	8,033	**8,463**
Annual SNL/NM Nonfatal Occupational Injury/Illness Rate	2.3	4.1	3.8	3.5	3.8	**3.5**

Sources: See Table 4.10–2, SNL/NM 1997a
SNL/NM: Sandia National Laboratories/New Mexico

number of workers that were either added to or subtracted from (percent increase or decrease) the 5-year average SNL/NM worker population under each alternative (see Table E.7–2).

The estimated SNL/NM worker population under each alternative was multiplied by the SNL/NM 5-year average nonfatal occupational injury/illness rate (per 100 workers) to obtain the total number of nonfatal occupational injuries/illnesses per year for the entire SNL/NM workforce for each alternative (see Table E.7–2).

E.7.2 Radiological Worker Doses/Health Risk

To evaluate the potential radiological impacts to SNL/NM employees for each alternative, the base year, 1996, was chosen by SNL/NM as most appropriate, based on reported worker-dose data from 1992 through 1996 (see Table 4.10–1). The selection process considered availability of data including material inventories, planned activities for each alternative, consistency with other resource areas that also established 1996 as the base year, and facility-based knowledge used in projecting operating levels for each alternative as reflected in the *SNL/NM Facility Source Documents* (SNL/NM 1998a). SNL/NM-projected operating levels contained in the S*NL/NM Facility Source Documents* include levels of radioactive materials to be processed and emitted as well as numbers of employees for facilities under all three alternatives.

The selection of the base year started with a review of the DOE annual occupational exposure report, which covers

Table E.7–2. Calculated Nonfatal Occupational Injuries/ Illnesses per Year for SNL/NM Workforce by Alternative

DATA ITEMS	5-YEAR AVERAGE[a]	NO ACTION ALTERNATIVE	EXPANDED OPERATIONS ALTERNATIVE	REDUCED OPERATIONS ALTERNATIVE
SNL/NM Worker Population Size Predicted Under Each Alternative	8,463	8,886 (5% Increase)[b]	9,309 (10% Increase)[b]	8,209 (3% Decrease)[b]
SNL/NM Nonfatal Occupational Injury/Illness Rate (per 100 workers or 200,000 hrs) 5-year Average (1992-1996)	3.5	3.5	3.5	3.5
Total Number of Nonfatal Occupational Injuries/ Illnesses for the Entire SNL/NM Workforce Predicted Under Each Alternative	296[c]	311[c]	326[c]	287[c]

Source: See Tables 5.3.12–1, 5.4.12–1, 5.5.12–1, and 4.10–2
[a] From Table E.7–1.
[b] Increase or decrease in the worker population above or below the 5-year average derived from 1992-1996 data (see Table E.7–1).
[c] Number of injuries/illnesses under each alternative = (population size) (5-year average injury/ illness rate)/100 workers
Note: If implemented, the Microsystems and Engineering Sciences Applications (MESA) Complex configuration would not change the nonfatal occupied injuries/illnesses per year under the Expanded Operations Alternative.

the measurable doses to individuals (includes all DOE, contractors, and visitors) by field office/operations by site/facility. The report on worker doses includes doses for all of SNL (including SNL/NM and SNL operations in California and at Tonopah, Nevada), Kirtland Air Force Base, Lovelace Respiratory Research Institute, and Ross Aviation. The analysis focused on exposures to radiation workers, which is consistent with the facility-based approach used in the *SNL/NM Facility Source Documents*. The term "radiation worker" is defined as a person having received an exposure of 10 mrem/yr or higher. The information provided by SNL/NM, based on their Radiation Exposure Monitoring System (REMS) data for the years 1992 through 1996, was considered and summarized in Table 4.10–1 for radiation worker average dose, maximum dose, and collective worker dose. The year 1996 was considered as a reasonable baseline, and the radiological operations were considered more representative of future operations compared to the years 1992 through 1995. The radiation worker doses for the 1996 base year were then used for future projections for worker doses under each of the alternatives.

SNL/NM provided the number of radiation workers and total FTEs for 1996. Because 1996 is considered representative for radiological operations in the future, the average worker dose and maximum worker dose are considered representative and consistent with 1996, and collective worker dose is projected based on change in radiation workers under each alternative. Annually, projected worker doses would likely fluctuate due to changes in operations, changes in prioritizing tests or other activities, changes in operating levels, and changes in personnel. At this time and based on the assumptions presented in the *SNL/NM Facility Source Documents*, the total worker doses projected over a 10-year period would likely bound impacts. Regardless, SNL/NM would continue to mitigate exposures through existing administrative controls such as shielding, remote operations, and multiple shifts to keep individual worker dose as low as reasonably achievable.

The SNL/NM REMS database dose information for 1996 presented the total collective worker dose of 12 person-rem, with a maximum individual worker dose of 845 mrem. The database also reported the total number of radiation-badged workers, those having an exposure dose greater than 10 mrem, as 258 out of a total monitored workforce of 18,750 (SNL/NM, contract employees, visitors). Based on this information, an average radiation-badged worker dose calculated for 1996 was 47 mrem/yr (12 x 1,000/258). Because only those badges with a 10-mrem or greater detected dose were used by REMS to calculate the average, maximum, and collective worker dose rates, only those badged workers were considered in the analysis as radiation-badged workers. Therefore, impacts to workers from radiation did not apply to nonradiation workers with badges because they did not have a detection of at least 10 mrem. The maximum worker dose and average worker dose were assumed to remain consistent with data assessed for the base year of 1996. Therefore, these values remained the same for all alternatives (Section E.6.1.1).

For each of the alternatives and for the base year of 1996, total FTEs were reported for radiation facilities (SNL/NM 1998a). There were 772 radiation facility FTEs for the base year of 1996, 1,068 radiation facility FTEs under the No Action Alternative, 1,192 radiation facility FTEs under the Expanded Operations Alternative, and 655 radiation facility FTEs under the Reduced Operations Alternative. From this information, a ratio of radiation-badged workers to total FTEs for the 1996 base year was calculated to be 0.334 (258/772). The number of radiation-badged workers was then estimated as 360 under the No Action Alternative, 400 under the Expanded Operations Alternative, and 220 under the Reduced Operations Alternative, assuming the same ratio of 0.334. The annual workforce collective dose was estimated by multiplying the average worker dose of 47 mrem by 360, 400, and 220 to obtain the collective dose under each alternative.

The health impacts to these projected workers were calculated and are presented in Tables E.7–3, E.7–4, and E.7–5 and summarized in Table E.7–6.

Table E.7–3. Radiation Doses (TEDE [a]) and Health Impacts to Workers from SNL/NM Operations Under the No Action Alternative

RADIATION WORKER DOSE RATES	RADIATION DOSE	RISK OF CANCER FATALITY
Annual Average Individual Worker Dose (mrem/year)	47[b]	1.9×10^{-5}
Annual Maximum Worker Dose (mrem/year)	845[b]	3.4×10^{-4}
Annual Workforce Collective Dose (person-rem/year)	17	6.8×10^{-3} [c]

Source: SNL/NM 1997k
mrem: millirem
[a] Average measured Total Effective Dose Equivalent (TEDE) means the collective TEDE divided by the number of individuals with a measured dose greater than 10 mrem.
[b] Annual average individual worker dose and maximum worker dose are expected to remain consistent with 1996 data.
[c] This represents the number of latent cancer fatalities in the workforce.
Note: Because not all badged workers are radiation workers, "radiation workers" means those badges with greater than 10 mrem measurements used in the calculations.

Table E.7–4. Radiation Doses (TEDE[a]) and Health Impacts to Workers from SNL/NM Operations Under the Expanded Operations Alternative[b]

RADIATION WORKER DOSE RATES	RADIATION DOSE	RISK OF CANCER FATALITY
Annual Average Individual Worker Dose (mrem/year)	47[c]	1.9×10^{-5}
Annual Maximum Worker Dose (mrem/year)	845[c]	3.4×10^{-4}
Annual Workforce Collective Dose (person-rem/year)	19	7.6×10^{-3} [d]

Source: SNL/NM 1997k
mrem: millirem
[a] Average measured Total Effective Dose Equivalent (TEDE) means the collective TEDE divided by the number of individuals with a measured dose greater than 10 mrem.
[b] If implemented, the Microsystems and Engineering Sciences Applications (MESA) Complex configuration would not change the radiation doses and health impacts to workers under the Exanded Operations Alternative.
[c] Annual average individual worker dose and maximum worker dose are expected to remain consistent with 1996 data.
[d] This represents the number of latent cancer fatalities.
Note: Because not all badged workers are radiation workers, "radiation workers" means those badges with greater than 10 mrem measurements used in the calculations.

Table E.7–5. Radiation Doses (TEDE[a]) and Health Impacts to Workers from SNL/NM Operations Under the Reduced Operations Alternative

RADIATION WORKER DOSE RATES	RADIATION DOSE	RISK OF CANCER FATALITY
Annual Average Individual Worker Dose (mrem/year)	47[b]	1.9×10^{-5}
Annual Maximum Worker Dose (mrem/year)	845[b]	3.4×10^{-4}
Annual Workforce Collective Dose (person-rem/year)	10	4.0×10^{-3} [c]

Source: SNL/NM 1997k
mrem: millirem
[a] Average measured Total Effective Dose Equivalent (TEDE) means the collective TEDE divided by the number of individuals with a measured dose greater than 10 mrem.
[b] Annual average individual worker dose and maximum worker dose are expected to remain consistent with 1996 data.
[c] This represents the number of latent cancer fatalities.
Note: Because not all badged workers are radiation workers, "radiation workers" means those badges with greater than 10 mrem measurements used in the calculations.

Table E.7–6. Summary of Calculated Radiation Doses and Health Effects to Workers Under Each Alternative

ALTERNATIVE	INDIVIDUAL WORKER				WORKER POPULATION			
	DOSE (mrem/yr)	RISK OF FATAL CANCER	RISK OF NONFATAL CANCER	RISK OF GENETIC DISORDERS	COLLECTIVE DOSE (person-rem)	TOTAL FATAL CANCERS	TOTAL NONFATAL CANCERS	TOTAL GENETIC DISORDERS
No Action	47	1.9×10^{-5}	3.8×10^{-6}	3.8×10^{-6}	17	6.8×10^{-3}	1.4×10^{-3}	1.4×10^{-3}
Expanded Operations[a]	47	1.9×10^{-5}	3.8×10^{-6}	3.8×10^{-6}	19	7.6×10^{-3}	1.5×10^{-3}	1.5×10^{-3}
Reduced Operations	47	1.9×10^{-5}	3.8×10^{-6}	3.8×10^{-6}	10	4.0×10^{-3}	8.0×10^{-4}	8.0×10^{-4}

Sources: SNL/NM 1997k, 1998a
mrem: millirem
yr: year
[a] If implemented, the Microsystems and Engineering Sciences Applications (MESA) Complex configuration would not change the radiation doses and health effects to workers under the Exanded Operations Alternative.

This page was intentionally left blank